A RAY TRACING DIGITAL COMPUTER PROGRAM FOR THE STUDY OF MAGNETOSPHERIC DUCT PROPAGATION

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-3055

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Prepared by
NASA Electronics Research Center

Scientific and Technical Information Division
OFFICE OF TECHNOLOGY UTILIZATION 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

FOREWORD

This NASA Special Publication is a documentation and discussion of a digital computer program used to conduct ray-tracing of electromagnetic waves in the magnetosphere. The publication consists of three sections. Section I contains a general description of the program and its capabilities. Section II assumes that the reader is aware of the scope of the program and provides all the information necessary for a non-programmer to run the program. Section III is a programming manual containing extensive information on the program structure. The program is designed to operate in the IBM 7094 IBSYS environment. It is written in Fortran IV but utilizes a MAP assembler subroutine to integrate the differential equations.

Ray-Tracing techniques are used extensively in the study and understanding of propagation of electromagnetic waves in any media (neutral, magneto-ionic, etc.). Combined with experimental data, the ray-tracing technique has served as a powerful tool in communications research. Data from NASA satellites (ISIS, Explorer, RAE, and the like) are better evaluated with the help of digital ray-tracing techniques. The present documented program has been used by the authors in studying the data from the ISIS topside sounder experiments. However, the program is applicable to any medium with suitable choice of models.

Jayaram Ramasastry

Edward J. Walsh

April 1969

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INTRODUCTION

This report consists of three sections. Each section is intended to be an independent treatment of a specified aspect of reader interest.

Section I contains a general description of the program so that the reader can gain a general idea of the program's capability.

Section II assumes that the reader is aware of the scope of the program and that he intends to use this program in ray tracing analyses. Section II contains all the detailed information necessary for a non-programmer to run the program.

Section III is a programming manual containing detailed information on the program structure.

This program is designed to operate in the IBM 7094 IBSYS environment. The basic program is written in FORTRAN IV but utilizes a MAP assembler subroutine to integrate the differential equations.

The program can be considered to consist of five major parts:

(1) An executive routine which governs program flow

(2) An input section to assess the initial data necessary to operate the program.

(3) An output which prints a history of the path of the ray and under option governs the generation of a plotting tape

(4) Three mathematical models which characterize the electromagnetic properties of the magnetosphere

(5) An integration routine which evaluates the differential equations

The ray-tracing technique has been used by many people in ionospheric and magnetospheric propagation research. Actual ray-paths and signal characteristics (like attenuation, path-loss, doppler shift, and refraction) in model atmospheres and ionospheres are computed using the ray-tracing program. Because of the high accuracy obtainable, the use of a high-speed digital computer is preferred to an analog machine for the integration of the ray equations.

The ray-tracing program used in our study is based on the Hamilton system of equations as derived in spherical polar coordinates by Haselgrove and extended by Grossi and Langworthy for the investigation of HF and VHF ionospheric propagation. The particular problem concerning our study is the guided propagation of high frequency radiowaves along the magnetic field lines of the Earth. Some of the echo traces appearing at virtual ranges greater than those of the normal vertical incidence echo traces on the topside-sounder ionograms have been explained in terms of guided propagation of radiowaves along the field-lines. The guided propagation along the field-line is made possible by field-aligned ionization irregularities (e.g., ducts and shells) of suitable scale sizes and enhancements or depletions. The irregularities are assumed to have thickness greater than the radio wavelength and hence act as waveguides or "ducts" to trap HF energy and produce the long-range echo traces. The guiding of rays along field-lines requires irregularities with a certain minimum transverse ionization gradient. Propagation between magnetic conjugate points or "conjugate ducting" occurs when the transverse ionization gradient exceeds the minimum required for guidance at the apex of the magnetic line of force. Conjugate echoes are recorded by the topside sounder receivers when the signal traverses to and from the conjugate reflection points along the magnetic field-line passing through the satellite. Knowing the satellite orbital parameters and the transmitted signal parameters, one could conduct ray-tracing utilizing realistic models for the magnetosphere. The ray-tracing program yields such useful information as the criteria for guidance, the group-delays of the trapped signals of various frequencies, and total path length traversed. Ray-tracing method is a powerful tool when used alongside experimental observations since it gives a better insight into the observed results.

I. GENERAL PROGRAM DESCRIPTION

Introduction

This section provides a general description of the capabilities of the program. Major emphasis is placed on the program input and output and the basic formulation of the differential equations.

The integration technique is discussed only briefly but reference is made to Appendix A where the integration package is described in detail.

The three models characterizing the electromagnetic properties of the magnetosphere (electron density, collision frequency and magnetic field) are discussed briefly in this section and their detailed descriptions are presented in Section III.

Main Program

The following equations form the basis of the ray tracing program. The first six equations are the Hamilton electromagnetic wave equations in spherical coordinates. The remaining five equations are additional functions of phase path length. All derivatives indicated with a dot are with respect to phase path length in km.

The ray is described in terms of position in spherical polar coordinates with origin at the center of the Earth and in terms of the components of the wave normal y_1, y_2, y_3 in the r, θ, ϕ directions, respectively. Figure 1 describes the ray position geometry in spherical coordinates.

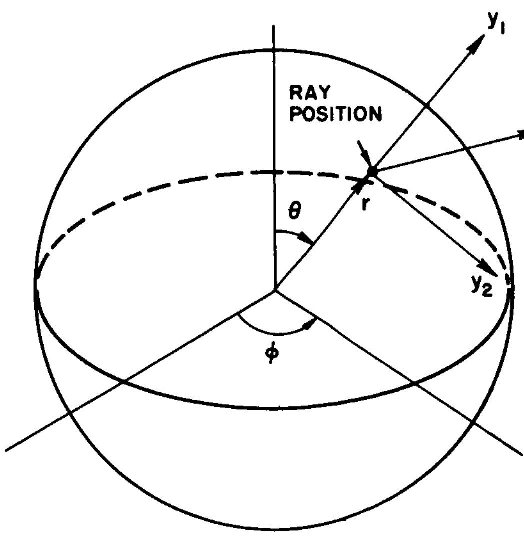


Figure 1. Ray Position in Spherical Coordinates.

Equation #		Initial Condition
1	$\dot{r} = \frac{1}{\mu^2}\left(y_1 - \mu \frac{\partial\mu}{\partial y_1}\right)$	$r(o) = r_o$
2	$\dot{\theta} = \frac{1}{\mu^2 r}\left(y_2 - \mu \frac{\partial\mu}{\partial y_2}\right)$	$\theta(o) = \theta_o$
3	$\dot{\phi} = \frac{1}{\mu^2 r\sin\theta}\left(y_3 - \mu \frac{\partial\mu}{\partial y_3}\right)$	$\phi(o) = \phi_o$
4	$\dot{y}_1 = \frac{1}{\mu}\frac{\partial\mu}{\partial r} + \dot{\theta} y_2 + \dot{\phi} y_3 \sin\theta$	$y_1(o) = y_1$
5	$\dot{y}_2 = \frac{1}{r}\left(\frac{1}{\mu}\frac{\partial\mu}{\partial\theta} - \dot{r} y_2 + \phi y_3 r\cos\theta\right)$	$y_2(o) = y_2$
6	$\dot{y}_3 = \frac{1}{r\sin\theta}\left(\frac{1}{\mu}\frac{\partial\mu}{\partial\phi} - \dot{r} y_3 \sin\theta - \dot{\phi} y_3 r\cos\theta\right)$	$y_3(o) = y_3$
7	$\dot{G} = 1 + \frac{f}{\mu}\frac{\partial\mu}{\partial f}$	$G(o) = 0.0$
8	$\dot{S} = \frac{1}{\mu c\phi s\alpha}$	$S(o) = 0.0$
9	$\dot{D} = -\frac{2K}{\mu} D$	$D(o) = 1.0$
10	$\dot{E} = \frac{1}{\mu}\frac{\partial\mu}{\partial\phi}$ and $\dot{\Delta} f = -\frac{f}{c}\dot{E}$	$E(o) = 0.0$ $\Delta f(o) = 0.0$
11	$\dot{P}_F = \frac{\nabla^2\tau}{\mu^2 c\phi s\alpha}$	$P_F(o) = 0.0$

where:

$\mu \equiv$ phase refractive index

$r \equiv$ geocentric radius of the wave front

$\theta \equiv$ colatitude of the wave front

$\phi \equiv$ longitude of the wave front

$(y_1, y_2, y_3) \equiv$ components of the wave normal in the θ, θ, and ϕ directions

$G \equiv$ group path length

$S \equiv$ ray path length

$D \equiv$ powerloss due to absorption

$E \equiv$ coefficient used to compute the doppler shift, see Section III

$P_F \equiv$ coefficient used to compute the doppler shift, see Section III

$\tau \equiv$ eikonal function that has the property that the surface τ = constant, is the geometrical wave front

$\alpha \equiv$ angle between the wave normal and the wave front

The powerloss calculation, Eq. (11), is optional and may be suppressed if this data is of no interest to the user.

A complete description of all calculations can be found in section III.

Input Section

The input routine is written with the aim of providing maximum control over the operation of the program and at the same time minimize the size of the input deck. The NAMELIST feature of FORTRAN IV is used because it gives the user maximum flexibility and also tends to minimize the careless errors usually associated with fixed format input statements.

The input data is divided into three major parts:

(1) The data required to describe the initial position, direction and characteristics of the ray

(2) Optional integration parameters

(3) Optional limits for the axes of the calcomp plots

The required program inputs are:

(1) Starting position and direction of the electromagnetic wave, which is referred to as a "ray"

(2) Integration stops or triggers which either temporarily or permanently halt the integration procedure

(3) Propagation frequency, and ray mode (ordinary or extraordinary)

(4) Output controls, print and plotting intervals

(5) Option indicators

(6) Optional input indicators

All optional parameters are preset in the program. If, however, any or all of these parameters must be changed, the program allows for easy modification of these nominal values.

For a complete description of all required and optional inputs, see section II.

Output Section

All output, with the exception of a list of the case inputs, is performed by subroutine OUTPUT. This subroutine not only prints a history of the path of the ray, but under option control governs the plotting of the data.

Printed output.- Results are printed whenever one of the following situations occur:

(1) A print time is reached. Print time is a function of phase path length. A print time occurs at $n \cdot \Delta hp$ where $n = 0,1,2,3\ldots$ and Δhp is some increment in phase path length, measured in kilometers.

(2) The rate of change of the geocentric radius, r, is approximately equal to zero.

(3) A stopping condition has been reached.

(4) A reflection has occurred.

The printed output consists of a sequence of 3 x 7 matrices grouped thirteen per page. The first matrix in the sequence, printed at the top of the page, is a heading matrix which identifies each data element of the data arrays. The heading definitions are listed below according to row and column.

Row	Column	Title	Description
1	1	PHASE PATH	Phase path length, hp, from (r_o, θ_o, ϕ_o) in kilometers.
1	2	RADIUS	Geocentric radius, r, of the ray position in kilometers.
1	3	COLATITUDE	Colatitude, θ, of the ray position, in degrees.
1	4	LONGITUDE	Longitude, ϕ, of the ray position, in degrees.
1	5	ABSORPTION	Absorption loss, D.
1	6	DOPPLER, SP	Doppler shift
1	7	POWER LOSS	Power loss, $\frac{P_{RO}}{P_T}$, exclusive of absorption
2	1	GROUP PATH	Group path length, G, in kilometers
2	2	Y_1	Vertical component, Y_1, of the wave normal
2	3	Y_2	Southerly component, Y_2, of the wave normal
2	4	Y_3	Easterly component, Y_3, of the wave normal
2	5	MU**2	Square of the Index of refraction (μ^2)
2	6	Y**2	$Y_1^2 + Y_2^2 + Y_3^2$
2	7	EPSTEIN CD	Epstein condition

Row	Column	Title	Description
3	1	RAY PATH	Ray path length, s, in kilometers
3	2	POLARIZATION -MOD AND ARG	Modulus and argument of the wave polarization term, R.
3	4	DEL MU	Validity criterion
3	5	N	Electron density, N, in electrons/cc
3	6	NU	Collision frequency, ν, in collisions/sec.
3	7	GROUP DELAY (Gd)	Group delay in milliseconds. (Group path length divided by the velocity of light in free space.)

An example of the printed output can be found in Table I. Whenever results are printed because of any one of the stopping conditions, an appropriate message is printed below the data to which the message refers.

Plotted output.- Each output plot consists of two plots. The rectangular plot shows the distance of the ray normal to the field line from the near end. The polar plot shows the actual ray path with reference to the surface of the Earth. The polar plot gives a clear indication of the positions of the conjugate reflection points as well as the L value of the field line guiding the rays. A complete description of the plotting routine can be found in section III.

Some examples of the plotted output are described in the following paragraphs.

Examples

Figures 2 through 4 show a few results of the ray tracing. They are chosen so as to demonstrate the capabilities of the program. Figure 2 is a single plot which simulates a conjugate echo path observed in an Alouette 2 ionogram. Figure 3 is an overlayed plot of two rays launched from the same point but with different launch angles, DELAO. Figure 4 is an overlayed plot of four rays launched from the same point with identical launch angles but at different frequencies.

Parameters shown in the figures are defined as follows:

RO = the geocentric radius in km of the initial signal position

TABLE I

EXAMPLE OF PRINTED OUTPUT

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
2.0000000E 01	9.3041084E 03	7.7566658E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4031575E 01	3.7083140E-01	8.4940216E-01	-0.0000000E-39	8.5899997E-01	8.5899995E-01	3.2884926E-13
2.1583306E 01	1.0000023E 00	-9.0000000E 01	2.1791243E-05	1.2074153E 03	8.6929314E-06	8.0105249E-02
2.0000000E 02	9.3790591E 03	7.8663387E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919784E 02	3.5227335E-01	8.6049035E-01	0.0000000E-39	8.6454017E-01	8.6454015E-01	1.8393076E-13
2.1547645E 02	1.0000086E 00	-9.0000000E 01	1.2532970E-05	1.1775214E 03	5.1706413E-06	7.9732613E-01
4.0000000E 02	9.4549106E 03	7.9885571E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618443E 02	3.1247831E-01	8.7869874E-01	0.0000000E-39	8.6975418E-01	8.6975416E-01	1.0242290E-13
4.3024053E 02	1.0000001E 00	-9.0000000E 01	7.7818205E-06	1.1486853E 03	3.0565067E-06	1.5872814E 00
6.0000000E 02	9.5232201E 03	8.1110764E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136256E 02	2.7305632E-01	8.9420238E-01	0.0000000E-39	8.7415765E-01	8.7415764E-01	6.0527487E-14
6.4441360E 02	1.0000071E 00	-9.0000000E 01	1.6612134E-05	1.1237326E 03	1.9024320E-06	2.3712085E 00
8.0000000E 02	9.5831912E 03	8.2340916E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506111E 02	2.4719298E-01	9.0372165E-01	0.0000000E-39	8.7781720E-01	8.7781718E-01	3.8245256E-14
8.5809700E 02	1.0000027E 00	-9.0000000E 01	2.1914030E-05	1.1025245E 03	1.2563415E-06	3.1502037E 00
1.0000000E 03	9.6338651E 03	8.3576100E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775500E 03	2.1059714E-01	9.1457866E-01	0.0000000E-39	8.8080530E-01	8.8080528E-01	2.5948592E-14
1.0713754E 03	1.0000034E 00	-9.0000000E 01	9.8592200E-06	1.0848494E 03	8.8431544E-07	3.0251668E 00
1.2000000E 03	9.6763511E 03	8.4814052E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090642E 03	1.6285635E-01	9.2559346E-01	0.0000000E-39	8.8324545E-01	8.8324544E-01	1.8751383E-14
1.2843241E 03	1.0000041E 00	-9.0000000E 01	1.0791444E-05	1.0700884E 03	6.5878622E-07	4.6968806E 00
1.4000000E 03	9.7104039E 03	8.6054828E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398141E 03	1.2611563E-01	9.3235042E-01	0.0000000E-39	8.8518248E-01	8.8518245E-01	1.4453184E-14
1.4970117E 03	1.0000010E 00	-9.0000000E 01	2.3180092E-05	1.0580794E 03	5.2030317E-07	5.4660469E 00
1.6000000E 03	9.7346377E 03	8.7296759E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699834E 03	9.5122531E-02	9.3677850E-01	0.0000000E-39	8.8660226E-01	8.8660225E-01	1.2002435E-14
1.7094989E 03	1.0000070E 00	-9.0000000E 01	1.5447359E-05	1.0490262E 03	4.3987898E-07	6.2332779E 00
1.8000000E 03	9.7496772E 03	8.8544160E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997386E 03	4.7070662E-02	9.4092793E-01	0.0000000E-39	8.8756100E-01	8.8756102E-01	1.0686431E-14
1.9216413E 03	1.0000001E 00	-9.0000000E 01	9.0264119E-06	1.0426152E 03	3.9635041E-07	6.9991287E 00
2.0000000E 03	9.7562792E 03	8.9790206E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292425E 03	5.3855051E-04	9.4239670E-01	0.0000000E-39	8.8811183E-01	8.8811182E-01	1.0141845E-14
2.1340939E 03	1.0000062E 00	-9.0000000E 01	1.7753554E-05	1.0385536E 03	3.7861936E-07	7.7641417E 00
2.0026441E 03	9.7562800E 03	8.9806684E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3322757E 03	-9.9151940E-05	9.4239864E-01	0.0000000E-39	8.8811521E-01	8.8811520E-01	1.0141433E-14
2.1368996E 03	1.0000064E 00	-9.0000000E 01	1.7272333E-05	1.0385236E 03	3.7861733E-07	7.7742522E 00

RD01 = -0.256018E-10

PKFRAC = the peak fractional ionization enhancement

LAMBDA = the colatitude of the field line

AO = the initial angle the ray makes with the local vertical

BO = the initial angle the ray makes with the south vector

DELAO = the initial angle the ray makes with a line drawn parallel to the tangent of the field line at RO

PHI & THETA = the magnetic longitude and colatitude of the initial signal position

HO = the scale size of the duct at the base of the field line

FREQ = the frequency of the initial signal

The ray mode (ordinary or extraordinary) is also indicated.

Each figure consists of two plots. The rectangular plot shows the distance of the ray normal to the field line versus the distance along the field line from the near end. The polar plot shows the actual ray path with reference to the surface of the Earth. The polar plot gives a clear indication of the positions of the conjugate reflection points as well as the L value of the field line guiding the rays.

All cases are for the L = 1.53 field line using a peak electron density enhancement of 5.0 percent at the point the ray is launched. The rays are all of the extraordinary mode.

In Figure 2 the ray has an initial geocentric radius of 9295.40 km. This corresponds to a distance of about 2.75 km from the field line at a colatitude of 77.445 degrees. The ray starts at about 4,500 km along the field line from its base in the northern hemisphere. It passes from north to south and is reflected in the southern hemisphere. After reflection it travels back into the northern hemisphere where it is again reflected. The program was deliberately stopped after the second reflection.

The slight bowing observed in the path of the ray near the equator is caused by the larger scale size near the equator. The larger scale size causes the enhancement structure to be wider. Thus, the ray rides further out from the field line.

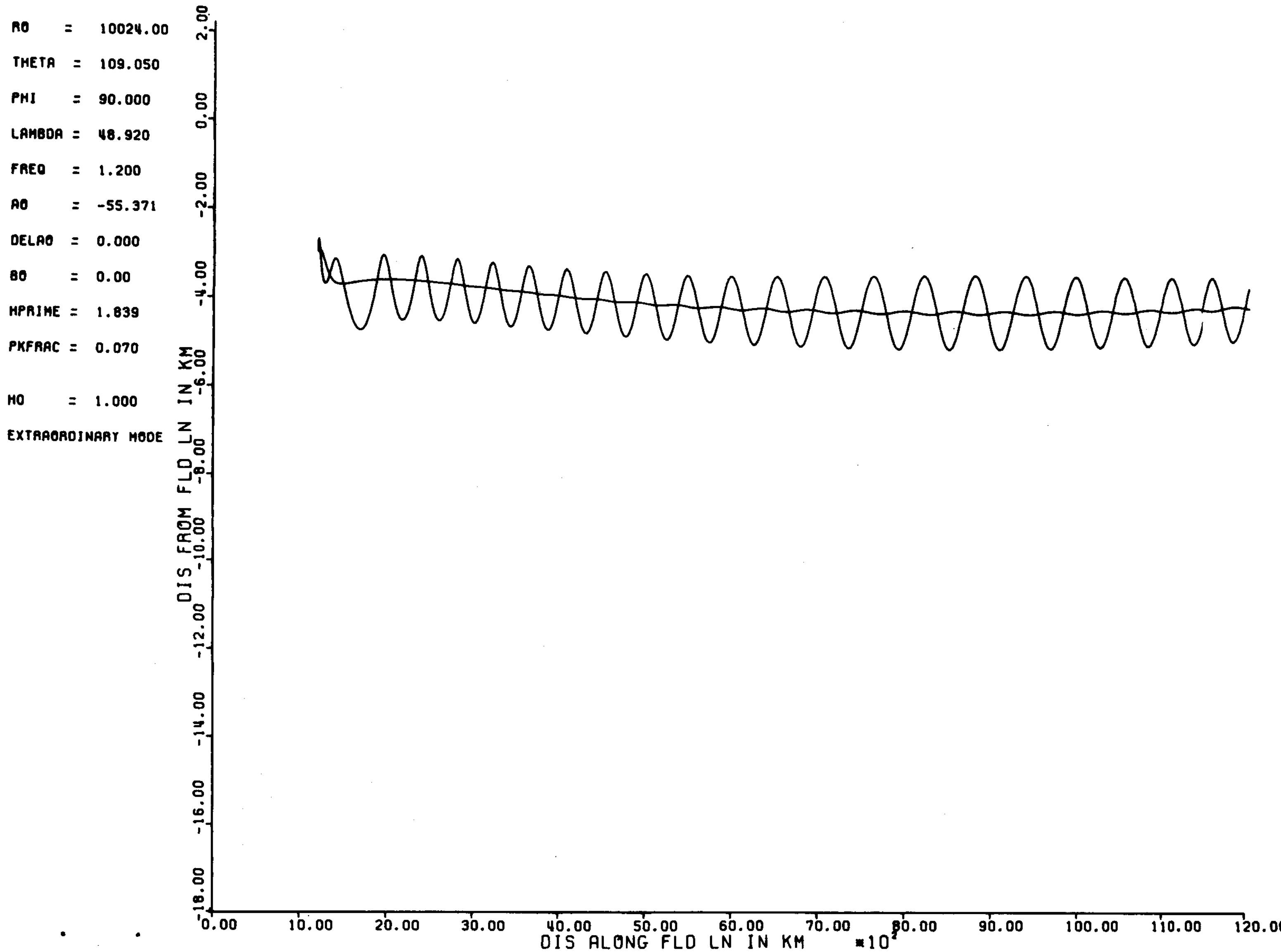


Figure 2A. - Single Plot Simulating a Conjugate Echo Path Observed in Alouette 2

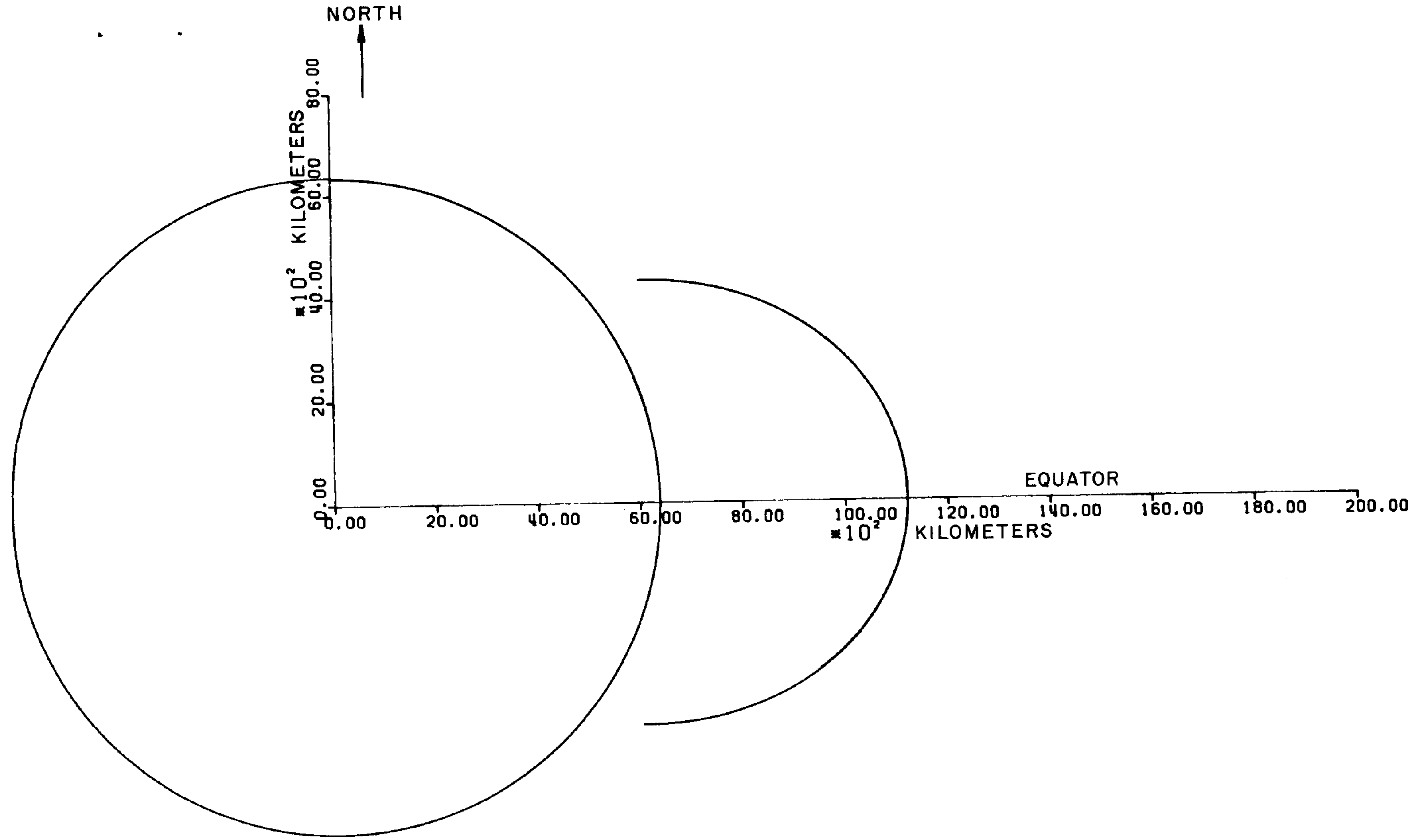


Figure 2B. - Single Plot Simulating a Conjugate Echo Path Observed in Alouette 2.

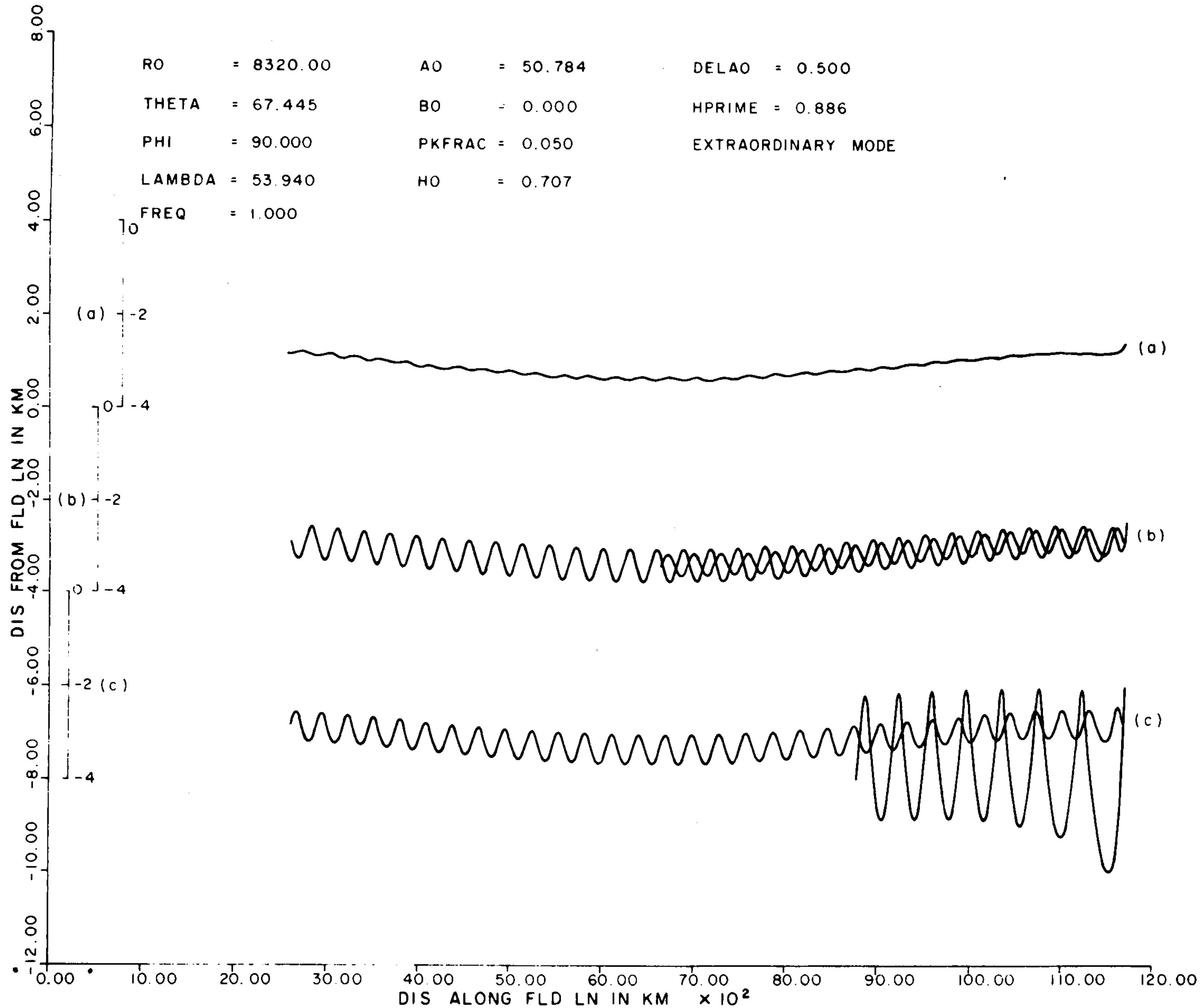


Figure 3. - Overlayed Plot of Two Rays Launched from the Same Point but with Different Launch Angles, DELAO

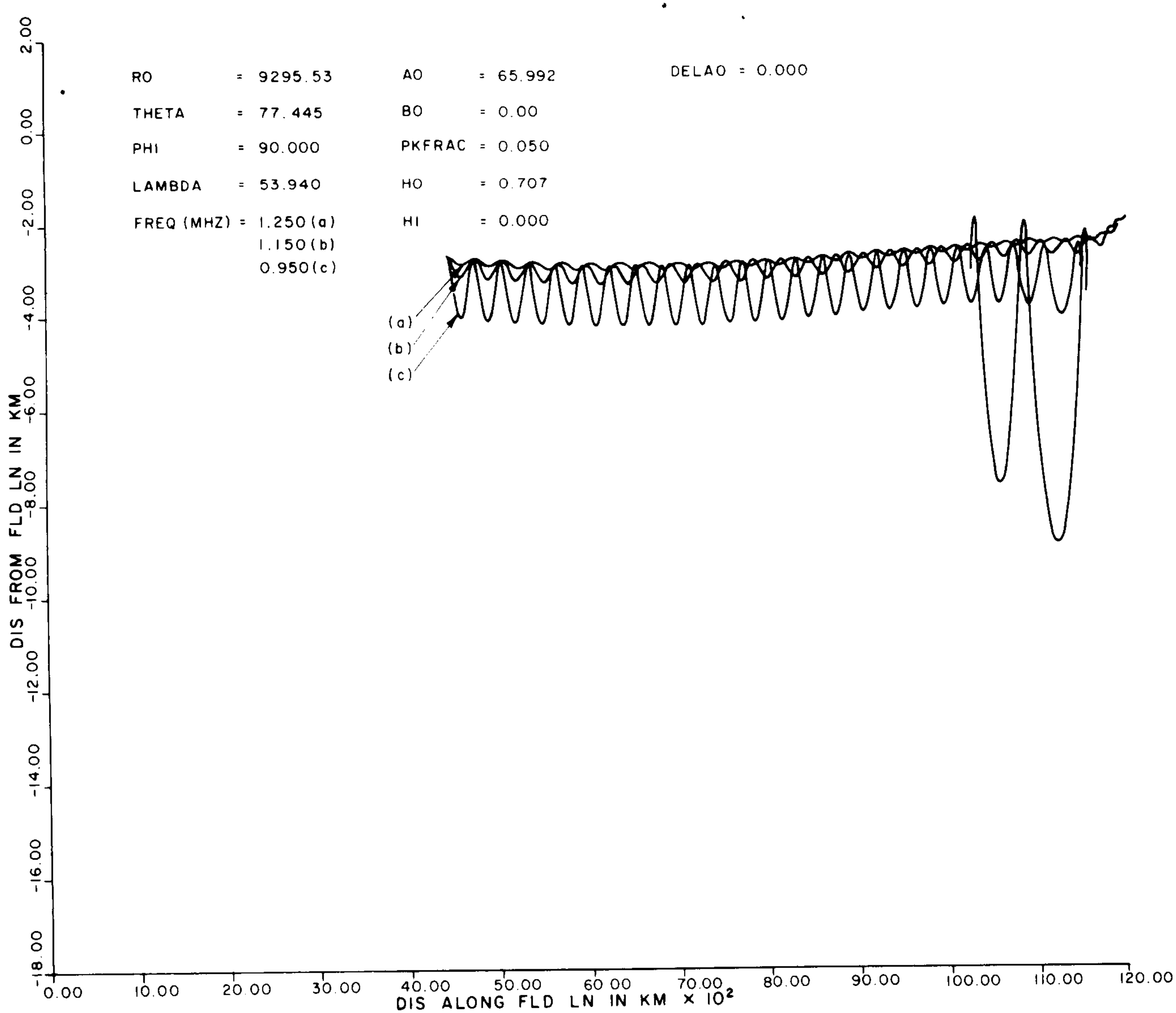


Figure 4A. - Overlayed Plot of Four Rays Launched

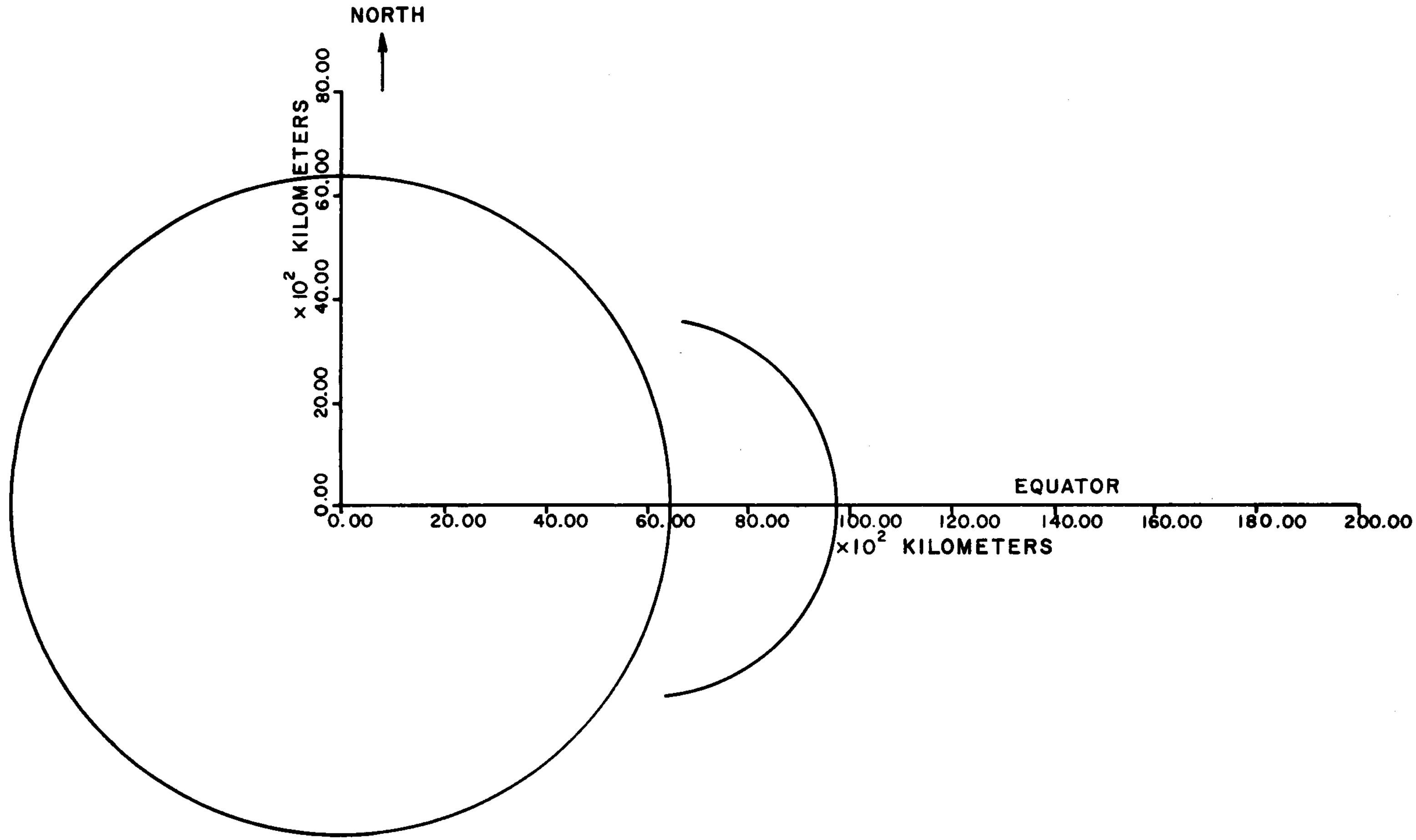


Figure 4B. - Overlayed Plot of Four Rays Launched

The oscillatory nature of the ray path seen in the rectangular plot is caused by the ray being launched at a point where the electron density gradient is greater than necessary for guidance. The ray tends to oscillate about a point where the electron density gradient is just sufficient to guide the ray parallel to the field line. A careful launching of the signal can minimize these initial oscillations. In this figure the oscillations were somewhat damped upon reflection. However, this is not always the case. For example, in Figure 4 the amplitude of the oscillations after reflection was actually increased.

Figure 3 shows three rays launched from the same point but with different launch angles, DELAO. The launch angles corresponding to plots (a), (b) and (c) are 0 degrees, - 0.5 degrees and + 0.5 degrees, respectively. The oscillatory nature of the ray paths in plots (b) and (c) once again demonstrates that the rays were launched off the equilibrium position. The rays started in the northern hemisphere about 2500 km along the field line and propagated along the field line to the southern hemisphere down to the reflection level. After reflection, they retraced their path and returned to the reflection level in the northern hemisphere and were again reflected. The program was stopped at this point because two reflections were counted.

In Figure 4, one can observe the behavior of waves at different frequencies. Three rays are launched from the same point with identical launch angles. The enhancement model is the same but the three rays differed in their frequencies. The three frequencies are 0.95, 1.15, and 1.25 MHz. The ray with a frequency of 0.95 MHz has the greatest amplitude of oscillation and the ray with the frequency of 1.25 MHz has the minimum initial oscillations. The rays were launched in the southern hemisphere at a colatitude of 77.445 degrees. The rays passed from south to north. Only one ray was reflected back into the duct at the conjugate reflection point. The other two escaped upon reflection. The inverse proportionality of the oscillation amplitude to frequency indicates that higher electron density gradients are required to guide the rays of higher frequencies.

Figures 5A, B; 5C, D, and 5E, F correspond to cases where a frequency of 1.2 MHz is trapped in enhancement ducts of different peak fractional enhancements. The ray launching position and the launch angle is the same for all the three cases. However, the peak fractional enhancements are 5, 6 and 7 percent for Figures 5A, 5C, and 5E, respectively. It may be noticed that in Figure 5A, the peak fractional enhancement of 5 percent is not sufficient to contain the ray on its way back from the reflection point in the northern hemisphere. Peak fractional enhancements of 6 and 7 percent as shown in Figures 5C and 5E seem sufficient to trap the rays and when the program was terminated after two reflections, the rays were still well trapped.

Magnetospheric Models

The following characterizes properties of the magnetosphere:

(1) The electron density distribution

(2) The magnetic field distribution

(3) The electron collision frequency distribution

The mathematical models for these quantities have been implemented in the form of subroutines and can be independently modified as necessary.

Magnetic field model.- A dipole model is used for the magnetic field of the Earth. The magnetic field equation which defines gyrofrequency, f_H, is given by:

$$f_H(r, \theta) = C_{11} \left(\frac{a}{r}\right)^3 \left[1 + 3 \cos^2\theta\right]^{1/2}$$

where a = 6378.0, the radius of the earth in km, and r and θ are the geocentric distance and colatitude of any point on the field line.

$$C_{11} = \frac{e}{2\pi m} B_o * 1.0E\text{-}6 \doteq 0.9$$

where B_O is the magnetic field on the surface of the Earth at the equator, and e and m are the charge and mass of an electron. A value of 0.3142 Gauss is used for B_o.

The angle between the magnetic field direction and the wave normal is given by

$$\cos\psi = \frac{2Y_1\cos\theta + Y_2\sin\theta}{\left[\left(\sum_{i=1}^{3} Y_i^2\right)\left(1 + 3\cos^2\theta\right)\right]^{1/2}}$$

$$\sin\psi = \frac{2Y_2\cos\theta = Y_1\sin\theta}{|2Y_2\cos\theta - Y_1\sin\theta|}\left(1-\cos^2\psi\right)^{\frac{1}{2}}$$

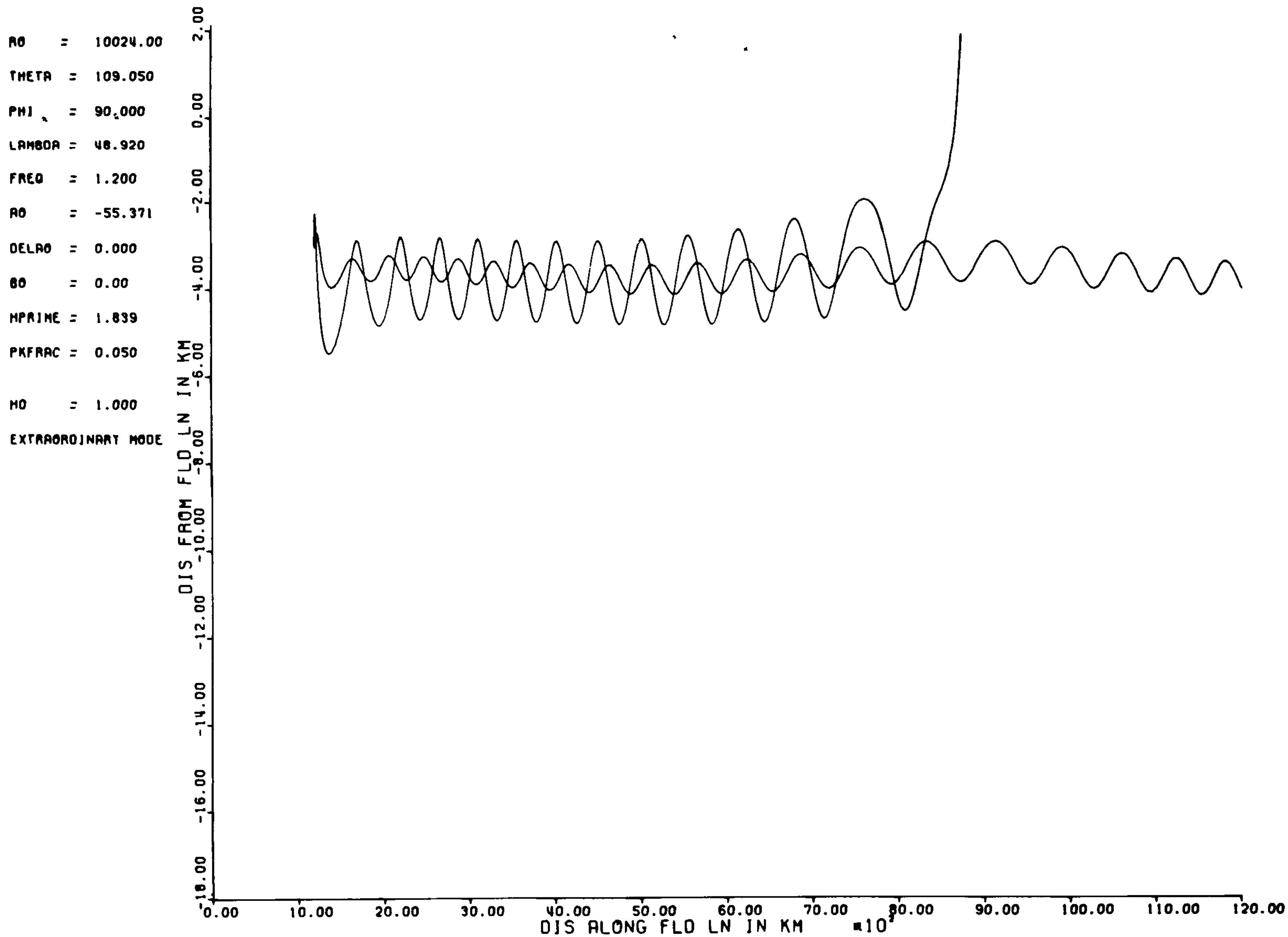


Figure 5A. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

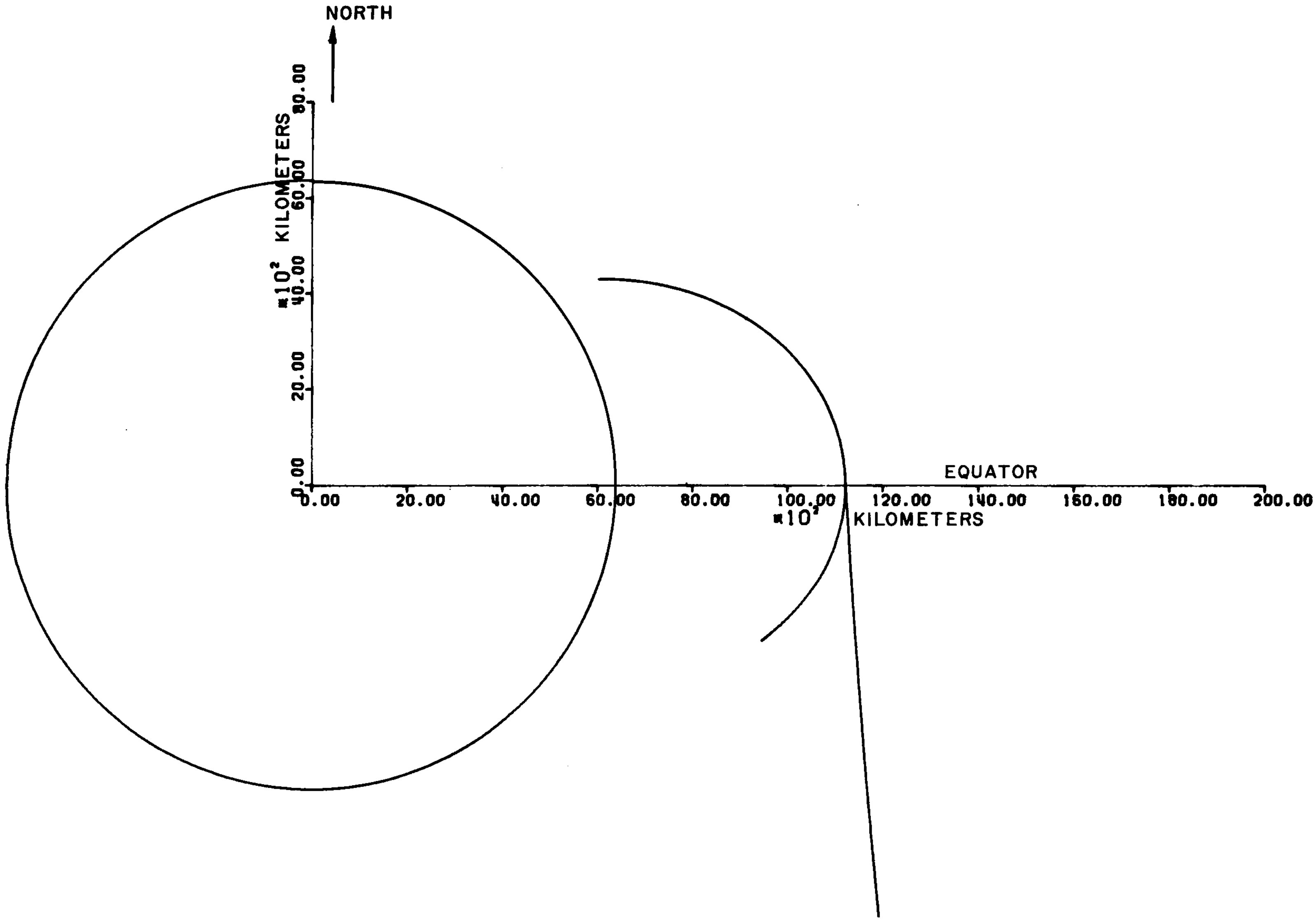


Figure 5B. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

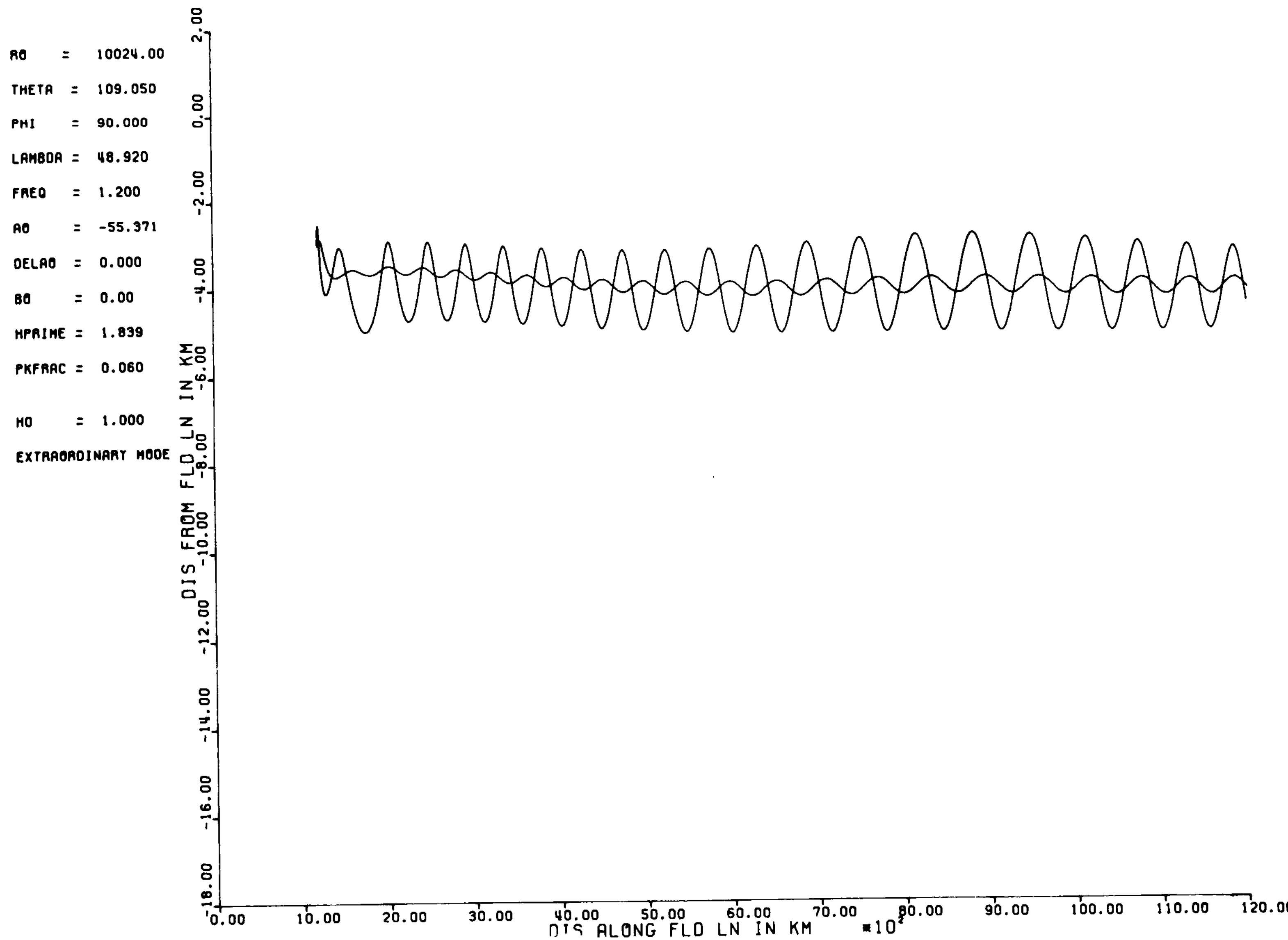


Figure 5C. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 5 Percent

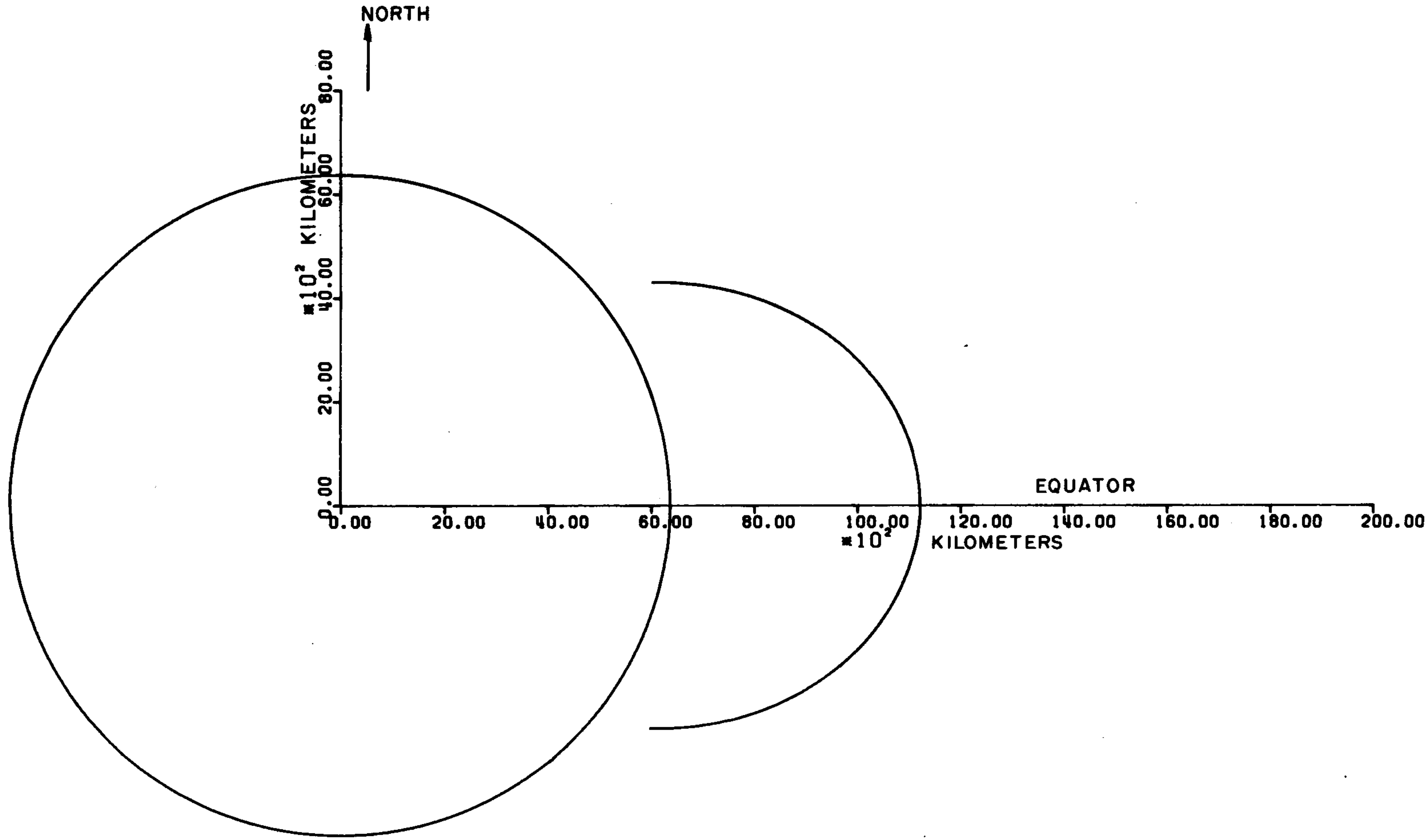


Figure 5D. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 6 Percent

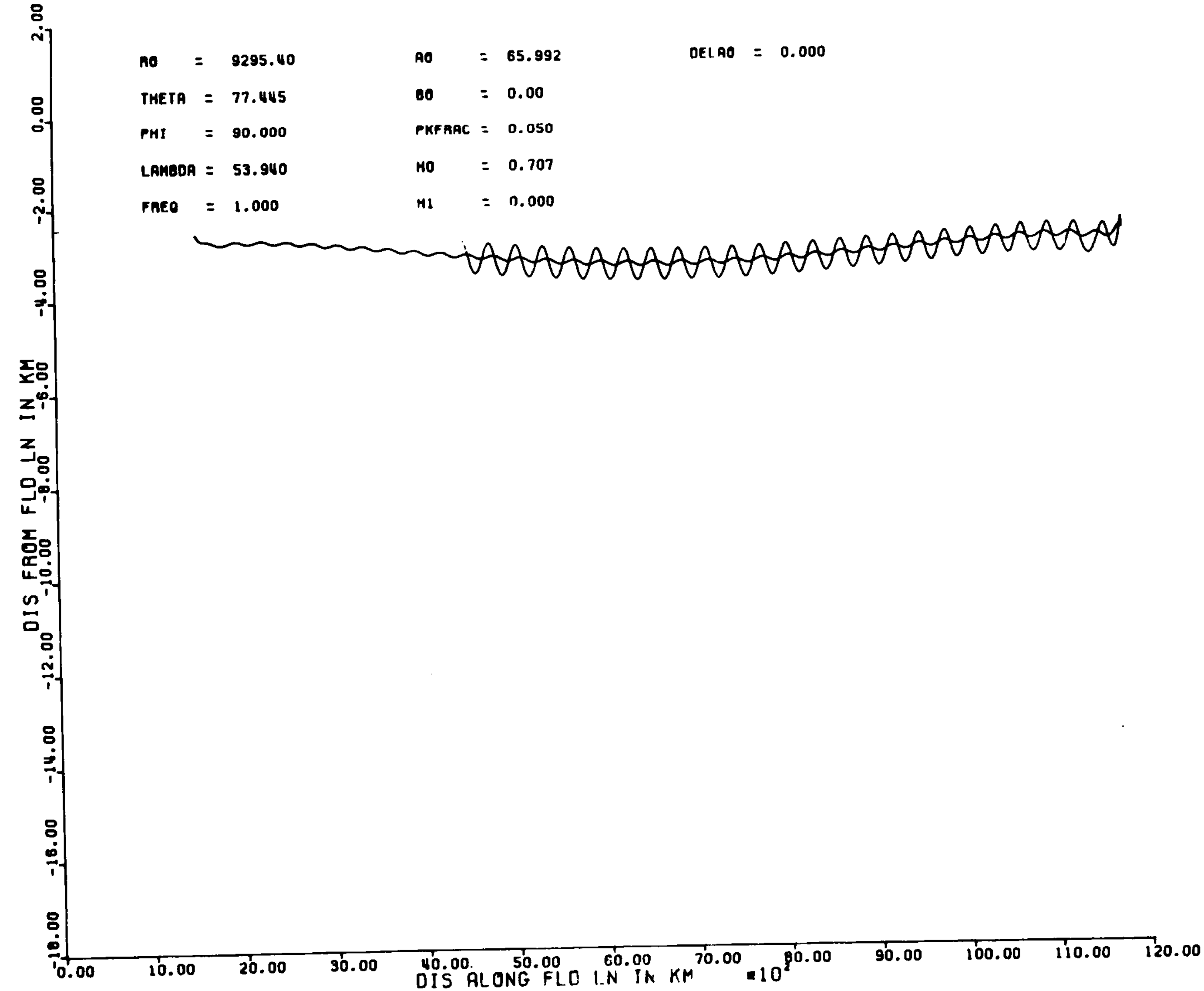


Figure 5E. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 7 Percent

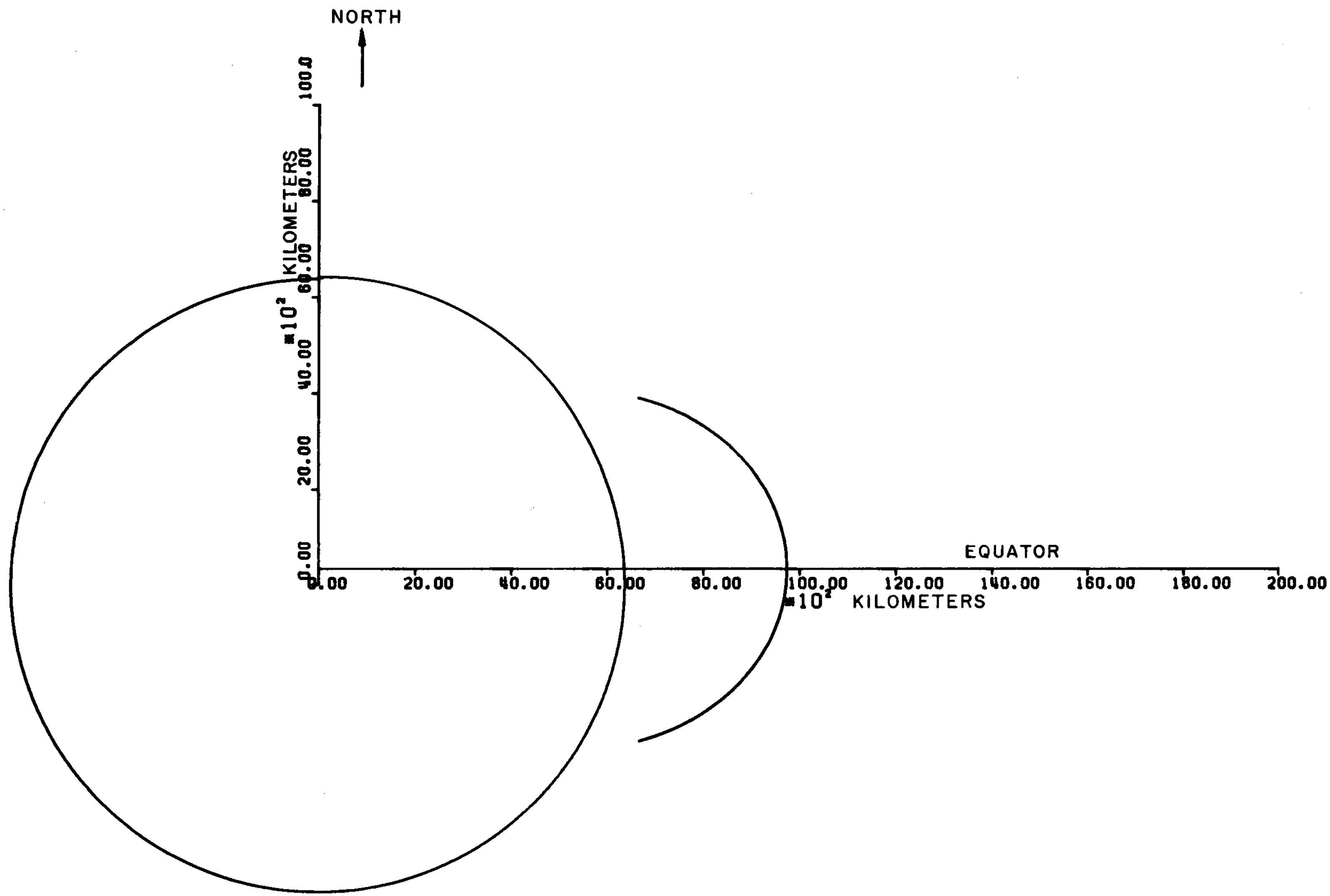


Figure 5F. - Ray Path of 1.2 MHz Signal Trapped in an Enhancement Duct. Peak Fractional Enhancement in the Duct at the Initial Ray Position is Equal to 7 Percent

But, the dipole model is highly idealized and lacks such features as local variations in the magnetic field strength. Its advantage lies in the fact that it saves a lot of computer time and for the ray-tracing problem under study, the microscopic features of the magnetic field are not necessary.*

Collision frequency model.- The collision frequency model has the following functional form:

$$\nu = 10^{\nu'}$$

where ν' is computed as shown below. The collision frequency profile as a function of altitude consists of three parts that are smoothly joined with the aid of a curve fitting program.

for $6378 \leq r \leq 6478$ km:

$$\nu' = 12.03527 - 0.07392\, x$$

where $x = (r-6378)\text{km}.$

for $6478 \leq r \leq 6853$ km:

$$\nu' = \sum_{i=1}^{6} \left[a_i + C(\theta, \phi) b_i \right] f_i(x)$$

where $f_1(x) = 1$; $x = (r-6478)\text{km}$

$$f_2(x) = x$$

$$f_3(x) = x^2$$

$$f_4(x) = x^3$$

$$f_5(x) = \cos(0.0157x)$$

*Those who are interested in using a better magnetic field model should refer to Langworthy (Smith) (1966) for a description of the Gaussian spherical harmonic magnetic field model.

$$f_6(x) = \sin(0.0157x)$$

$$a_1 = 5.0562 \qquad ; b_1 = 0.032512$$

$$a_2 = -3.7482\mathrm{x}10^{-2} \qquad ; b_2 = -0.8847\mathrm{x}10^{-2}$$

$$a_3 = 1.3864\mathrm{x}10^{-4} \qquad ; b_3 = 0.8541\mathrm{x}10^{-4}$$

$$a_4 = 1.4777\mathrm{x}10^{-7} \qquad ; b_4 = -1.5422\mathrm{x}10^{-7}$$

$$a_5 = -0.48192 \qquad ; b_5 = 0.01470$$

$$a_6 = -0.27021 \qquad ; b_6 = 0.65037$$

$$C(\theta, \phi) = C_1\theta^2 + C_2\theta + C_3 + (d_1\theta^2 + d_2\theta + d_3) \cos\phi$$

where

$$C_1 = -0.35818 \qquad ; d_1 = -0.17828$$

$$C_2 = 1.1250 \qquad ; d_2 = 0.55997$$

$$C_3 = -0.88344 \qquad ; d_3 = 0.56028$$

θ is the colatitude and ϕ is the longitude in degrees. Symbol $\phi = 0$ corresponds to local noon.

For $r \geqslant 6853$ km,

$$\nu' = 2.3653-0.0030266x + (0.3195-0.0000536x)\, C(\theta, \phi)$$

where

$$x = (r-6853)$$

Electron density model.- The model for the electron density distribution incorporates those features that have a bearing on the high-frequency ducting problem. Thus, an ionization irregularity (duct) model is superimposed on the normal radial distribution of electron density. The duct structure is aligned along the magnetic field.

A complete description of the electron density model can be found in section III.

Integration Package

Because of the high accuracy obtainable, the use of a digital computer is preferred to an analog machine for the integration of the ray equations. The method used solves the first n of a set, N, of first-order differential equations simultaneously. The Adams-Moulton open and/or open and closed formulas are used. A Runge-Kutta fourth-order integrator is used as a starting routine to generate the necessary differences. Provision is made for interrupting the integration process at specific values of either the independent or dependent variables. The order of differences used in the Adams-Moulton mode is less than or equal to nine.

A complete description of the integration package is found in Appendix A.

II. USER'S MANUAL

Introduction

This User's Manual is intended to supply all the information and guidelines necessary for a non-programmer to operate the ray-tracing program.

Inputs

In order to facilitate using this program, the NAMELIST feature of FORTRAN IV is used. This input mode has two distinct advantages over a fixed format statement:

(1) It minimizes keypunching errors

(2) When stacking cases, it minimizes the size of the input deck

NAMELIST allows for a free format input stream; the data can be placed anywhere on the card and spaced in any convenient manner. The basic rules the user must keep in mind when constructing an input deck are outlined in section III. For a detailed description of the NAMELIST feature see IBM form C28-6390.

<u>IBM 7090-7094 IBSYS operating system, version 13, FORTRAN IV language</u>.- It has been found that when stacking data sets for running as many cases as possible, there is usually some similarity among sucessive sets. NAMELIST allows the user to take maximum advantage of any similarity.

The first data set in the stack must contain all data required by the program for normal operation. Each successive data set, however, must specify only those parameters whose values differ from immediately preceding case.

We consider the input data to be of three distinct types:

(1) Data which is required for the normal operation of the program and must be supplied by the user

(2) Optional integration control parameters

(3) Optional plotting limits

Detailed descriptions of these three data types can be found in the following paragraphs.

<u>Input dictionaries</u>.- The input is under control of three dictionaries. The first dictionary, XNAME1, refers to the required program inputs. The remaining dictionaries, XNAME3 and XNAME5, refer to the optional integration and plot parameters, respectively.

Required input - XNAME1.- Figure 6 shows a sample input deck for the required inputs. The dictionary for these inputs consists of five names: D, LAST, NTITLE, NCONST, and LIMITS. The first name, D, is a 28-word array containing all the data about the initial position of the ray, direction and ray characteristics. The four remaining names are single word indicators. An explanation of each of the required inputs follows.

D array.- Table II contains an item by item description of each of the parameters in the D array. The subscript shown in the left-hand column indicates the position in the array. The subscript of the first item must be punched and then the remaining items will be stored sequentially. Figure 7 is a graphical illustration of the initial ray-position input parameters specified by D(1) through D(6).

TABLE II

D ARRAY

D	DESCRIPTION
1	Initial geocentric radius, r_o, in kilometers
2	Initial colatitude, θ_o, in degrees. $(0 \leq \theta \leq 180)$
3	Initial longitude, ϕ_o, in degrees. $(0 \leq \phi \leq 360)$
4	Initial ray angle, A_o, with respect to the local vertical, in degrees. $(0^o \leq A_o \leq 180^o)$ NOTE A_o is no longer a program input. A_o is calculated from ΔA_o. However, the location D(4) is still reserved for A_o.
5	Initial ray angle, B_o, with respect to the south vector, in degrees. $(0^o \leq B_o \leq 360^o)$
6	Initial ray angle, ΔA_o, with respect to the tangent of the field line in degrees. $(0 \leq \Delta A_o \leq 180^o)$
7	Maximum allowable geocentric radius, R_{max}, in kilometers

TABLE II.- Continued

D ARRAY

D	Description
8	Minimum allowable geocentric radius, R_{min}, in kilometers
9	Maximum allowable colatitude, θ_{max}, in degrees. ($0^{\circ} \leqslant \theta_{max} \leqslant 180^{\circ}$)
10	Minimum allowable coatitude, θ_{min}, in degrees. ($0^{\circ} \leqslant \theta_{min} \leqslant 180^{\circ}$)
11	Maximum allowable longitude, ϕ_{max}, in degrees. ($0^{\circ} \leqslant \phi_{max} \leqslant 360^{\circ}$)
12	Minimum allowable longitude, ϕ_{min}, in degrees. ($0^{\circ} \leqslant \phi_{min} \leqslant 360^{\circ}$)
13	Print interval in kilometers. Printed output is keyed to phase path length
14	Plot interval in kilometers. Plotted output is keyed to phase path length. It has nothing to do with the Print Interval. It is only a control of the spacing of the points to be plotted.
15	Nominal integration step size, in kilometers. Integrations are with respect to phase path length
16	Wave frequency, F, in megacycles per second
17	Ray type indicator: Set equal to 1 for ordinary type, or Set equal to -1 for extraordinary type
18	Reflection indicator: Set equal to 2 if reflection is desired, 0 otherwise. Ordinarily, reflection occurs whenever the rate of change of geocentric radius goes to zero
19	Powerloss calculation indicator: Set equal to 1 if computation is desired, 0 otherwise

TABLE II.- Concluded

D ARRAY

D	Description
20	Plot option indicator: Set equal to 1 if plotting is desired, 0 otherwise
21	Plot overlay option indicator: Set equal to 1 if overlaying of successive plots is desired, 0 otherwise. Ignored if NPLOT = 0
22	Automatic positioning of ray at point of maximum electron density gradient indicator: Set equal to 1 if automatic positioning is desired, 0 otherwise
23	Scale size of the ionization irregularity at the base of the field line H_o
24	Peak fractional enhancement at (r_o, θ_o, ϕ_o) where r_o is the initial geocentric radius, θ_o is the initial colatitude and ϕ_o is the initial longitude
25	Colatitude, λ, in degrees of the field-line passing through the initial ray position.
26,27,28	Not used

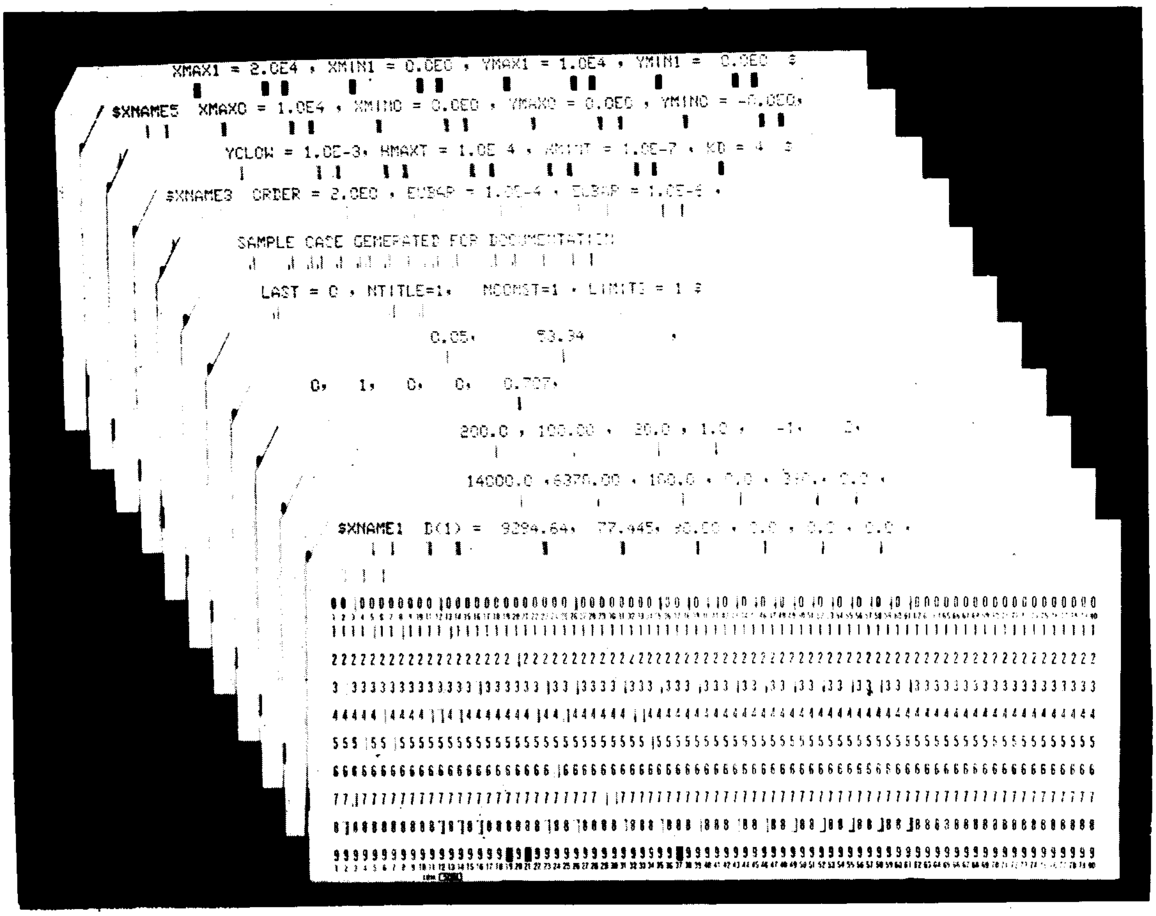


Figure 6. - Sample Deck Setup

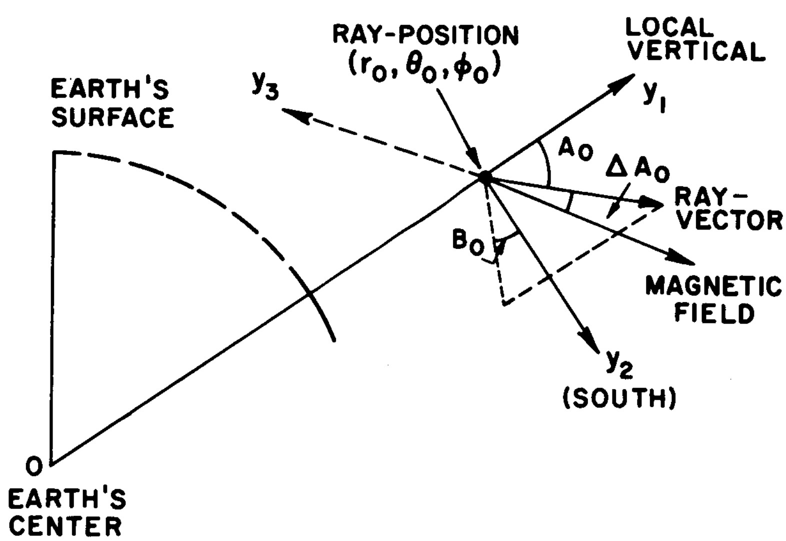


Figure 7. - Initial Ray - Position Inputs

Required indicators.- The remaining inputs under control of XNAME1 are four indicators described in Table III.

TABLE III

REQUIRED INPUT INDICATORS

Name	Description
LAST	Last Case Indicator: The program assumes LAST = 0, so the last case to be executed must explicitly set this parameter to 1
NTITLE	Optional Title Information: NTITLE preset to 0. If some identification is to be printed, set NTITLE = 1
NCONST	Optional Input Indicator, Integration Parameters: The program assumes NCONST = 0. If the integration parameters are to be changed, set NCONST = 1
LIMITS	Optional Input Indicator, Plotting Limits: The program assumes LIMITS = 0. If the plotting limits are to be changed set LIMITS = 1

Optional input.- The parameters described here are preset by the program. However, the user can replace any subset of these parameters by setting the values of NCONST and/or LIMITS equal to 1 and then punching a set of data cards using the dictionary XNAME3 and/or XNAME5. These cards must follow the statement card if NTITLE = 1 or immediately following the required inputs if NTITLE = 0.

Integration parameters - XNAME3.- The optional integration parameters are under control of the dictionary XNAME3. The dictionary contains seven names representing seven data items. Table IV defines each parameter and gives its nominal value. Appendix A contains a description of the integration routine.

TABLE IV (XNAME3)

Integration Parameters

Name	Nominal Value	Description
ORDER	1.0	Precision option. When set to 0 the integration is carried out in partial double precision, set to 1.0 integration is performed in full double precision
EUBAR	1.0E-5	Maximum integration error. When the integration error is greater or equal to this value the integration interval is halved
ELBAR	1.0E-7	Minimum integration error. When the integration error is less than or equal to this parameter the integration step is doubled
YCLOW	1.0E.7	Minimum value of the dependent variable. If the dependent variable is less than or equal to this parameter no halving will take place
HMAXT	1.0E+4	Maximum integration step. The integration step is not permitted to exceed this value
HMINT	1.0E-7	Minimum integration step. The integration step is not allowed to be smaller than this input
KD	4	Type of integration (must always equal 4)

Plot limits (XNAME5).- The optional plot limits are under the control of dictionary XNAME5. This dictionary contains eight names. Table V defines each limit and its nominal value.

TABLE V (XNAME5)

PLOT LIMITS

Name	Nominal Value	Description
XMINO	0.0	Minimum value of the X-axis for the rectangular plot.
XMAXO	1.20E4	Maximum value of the X-axis for the rectangular plot.
YMINO	-18.0	Minimum value of the Y-axis for the rectangular plot.
YMAXO	+2.0	Maximum value of the Y-axis for the rectangular plot.
XMIN1	0.0	Minimum value of the X-axis for the Polar Plot.
XMAX1	2.0E4	Maximum value of the X-axis for the Polar Plot.
YMIN1	0.0	Minimum value of the Y-axis for the Polar Plot.
YMAX1	1.0E4	Maximum value of the Y-axis for the Polar Plot.

Input conventions.- The following is a listing of a few simple rules the user must keep in mind when constructing an input deck:

1. Column 1 of each input card is not to be used. Any information punched in this column will be ignored.

2. The first character encountered by the input system must be a dollar sign ($) punched in column 2 of the first card of each group of inputs.

3. All data must be separated by commas. The input system assumes that any single input quantity must lie between an equal sign and a comma, or between two commas.

4. All numerical data can be entered in either a fixed decimal or exponential format. Whenever a decimal point does not appear within a number, in the case of the fixed decimal format, the system assumes that it is in front of the separator and all trailing blanks (i.e., no punches) will be

converted to zeroes. In the case of the exponential format the decimal point is assumed to lie to the right of the least significant digit. As an illustration, the following list of numbers will have identical binary representations in core storage:

2500.0	
25bb	fixed decimal (b-blank, no punch)
25E+2	
2.5E+3	exponential format

Note that in the above illustration the exponent is separated from the significant part of the number by the letter E.

5. The NAME LIST system allows for continuation cards. If continuation cards are used then the user must be careful in placing the input cards in proper order. When using continuation cards the name of the table, (array) need not be repeated. The only limitations are that column 1 is not to be used and each card must end with a comma.

   This program allows the user to execute several cases within a single run. This is done by first setting the indicator, NA, equal to zero within the first set of input and then for each of the following cases simply punch the dictionary name with the proper system symbols and then specify only those inputs which are to differ from the immediately preceding case. The inputs for each case are then placed behind each other, no separator cards are required, and the resulting input deck is placed behind the binary deck as described earlier.

6. The end of an input string is indicated by a dollar sign ($). The input system will continue reading until the second dollar sign is encountered.

Operating Instructions

Deck setup.- The following is a list of the control cards necessary to compile and execute the program in source form:

```
CC     CC     CC
 1      8     16

  $JOB D3121A 1 ERC J. Ramasastry - TRACE
  $EXECUTE      IBJOB
  $IBJOB        FIOCS
```

```
$IBFTC MAIN
                MAIN PROGRAM          (SOURCE)
$IBFTC INPU
                SUBROUTINE INPUT      (SOURCE)
$IBFTC OUTPU
                SUBROUTINE OUTPUT     (SOURCE)
$IBFTC FIEL
                SUBROUTINE FIELD      (SOURCE)
$IBFTC DENS
                SUBROUTINE DENSE      (SOURCE)
$IBFTC COL
                SUBROUTINE COLL       (SOURCE)
$IBFTC CALCO
                SUBROUTINE CALCO4     (SOURCE)
$IBFTC SCA
                SUBROUTINE PRAM       (SOURCE)
$IBFTC FORC
                SUBROUTINE FORCE      (SOURCE)
$IBFTC POLA
                SUBROUTINE POLAR      (SOURCE)
$IBFTC POWER
                SUBROUTINE POWERL     (SOURCE)
$IBFTC MARS
                SUBROUTINE MARK       (SOURCE)
$IBFTC SMK2
                SUBROUTINE SMARK      (SOURCE)
```

```
$IBFTC CST
                    SUBROUTINE CSINT        (SOURCE)
$IBFTC MIN
                    SUBROUTINE MINV         (SOURCE)
$IBFTC TO
                    SUBROUTINE TOR          (SOURCE)
$DATA
 '                  DATA DECK
 '         END OF FILE CARD
```

<u>I/O assignments</u>.- The program uses the standard ERC-IBM 7094-II assignments. The FORTRAN IV logical units are 5 and 6, respectively. If a plot is to be generated a tape must be mounted on SYSUT7.

<u>Abnormal termination</u>.- The program recognizes three types of abnormal terminations:

(1) An error in the integration routine. The message, ERROR RETURN FROM MARK is printed. The program will continue on to the next case.

(2) $\mu^2 \leqslant 0$

The message, THE VALUE OF EMUS IS NEGATIVE is printed. The program will continue on to the next case.

(3) $1 - x \leqslant 0$

The message, THE VALUE OF TERM IS NEGATIVE is printed. The program will continue on to the next case.

III. PROGRAMMER'S MANUAL

Introduction

This Programmer's Manual contains all the technical information required by a programmer whose task it may be to modify the program.

Each subroutine is described separately. Each description generally consists of:

(1) The mathematical formulation of the computations

(2) A flow chart of the routine

(3) A dictionary of the FORTRAN variables calculated in the routine

Following the subroutine descriptions the labeled COMMON statements are correlated with the subroutines in which they are used.

Source statement lists of all the subroutines are provided in Appendix B.

Main Program

Description.- The main program, MAIN, serves as an executive routine. (See flow chart in Figures 8A to 8H.) The functions of MAIN are:

(1) Initialization of the integration routine

(2) Computation of the derivative box

(3) Handling of trigger stops

The integration routine has a return indicator, NRTN, which, when tested, determines the order of calculations.

Upon return from the integration routine, the variable NRTN is set to an integer value from 1 to 5. NRTN is used to control program flow. Table VI indicates the action taken when NRTN assumes a particular value.

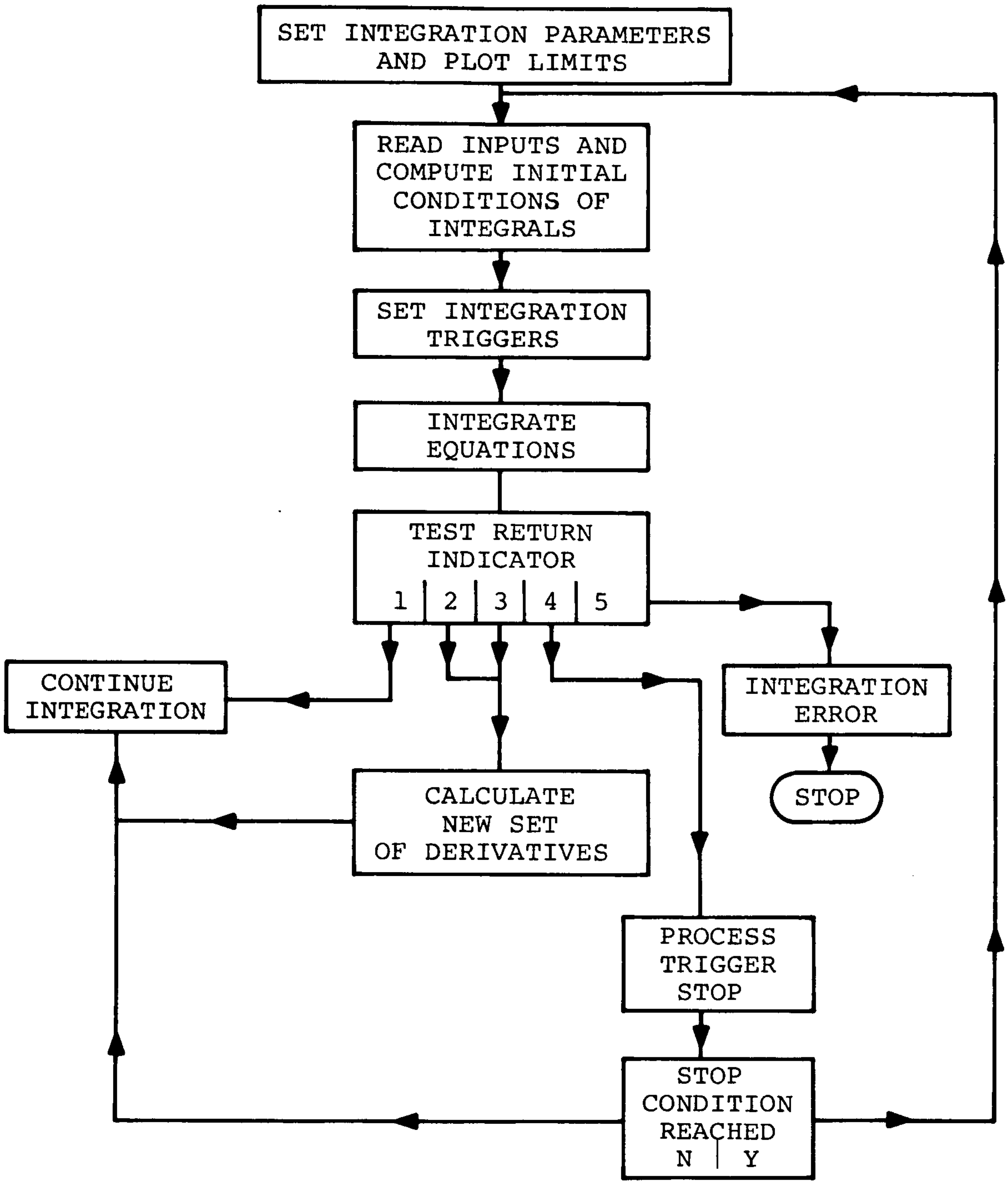


Figure 8A. - Flow Chart of Main Program

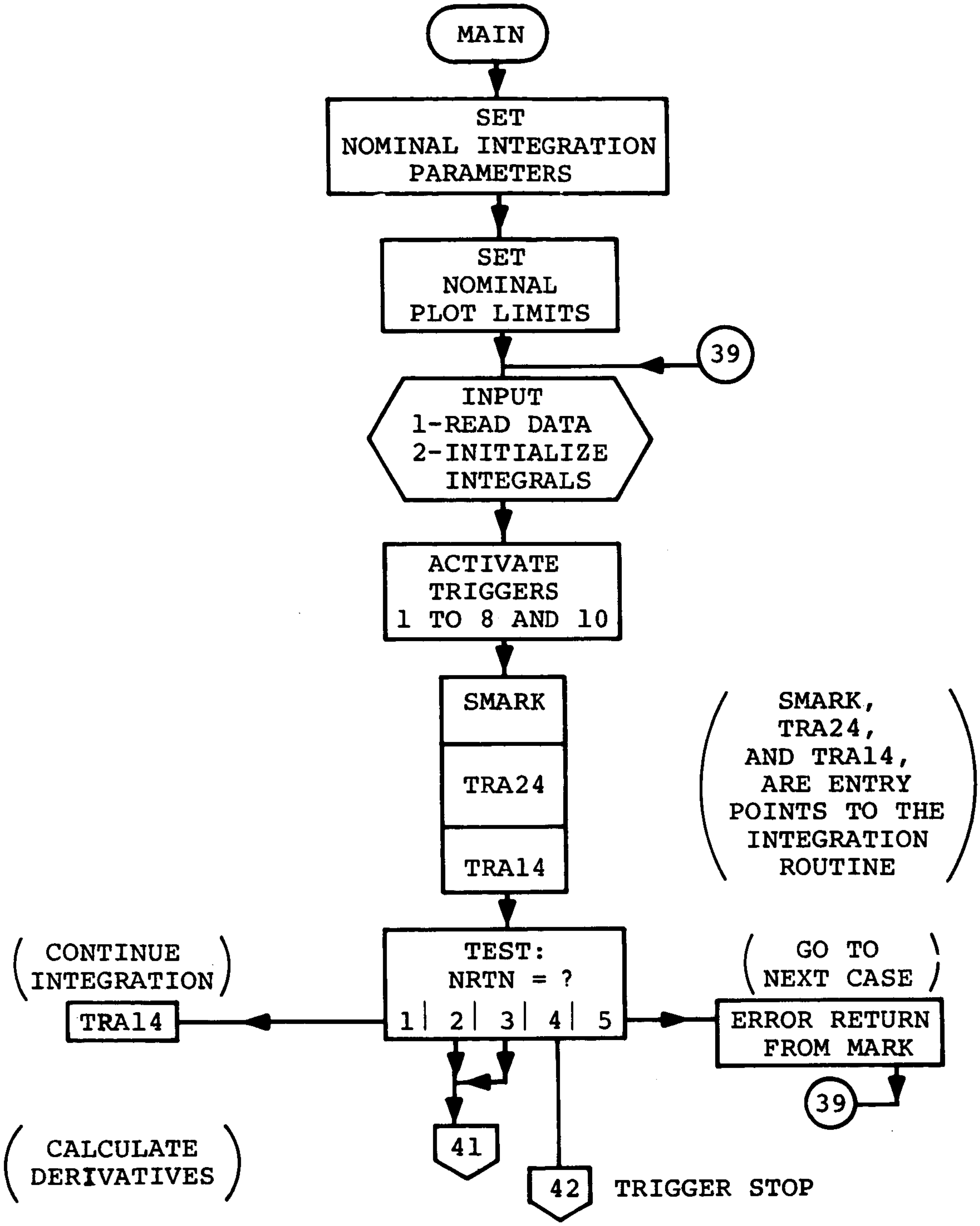


Figure 8B. - Flow Chart of Main Program

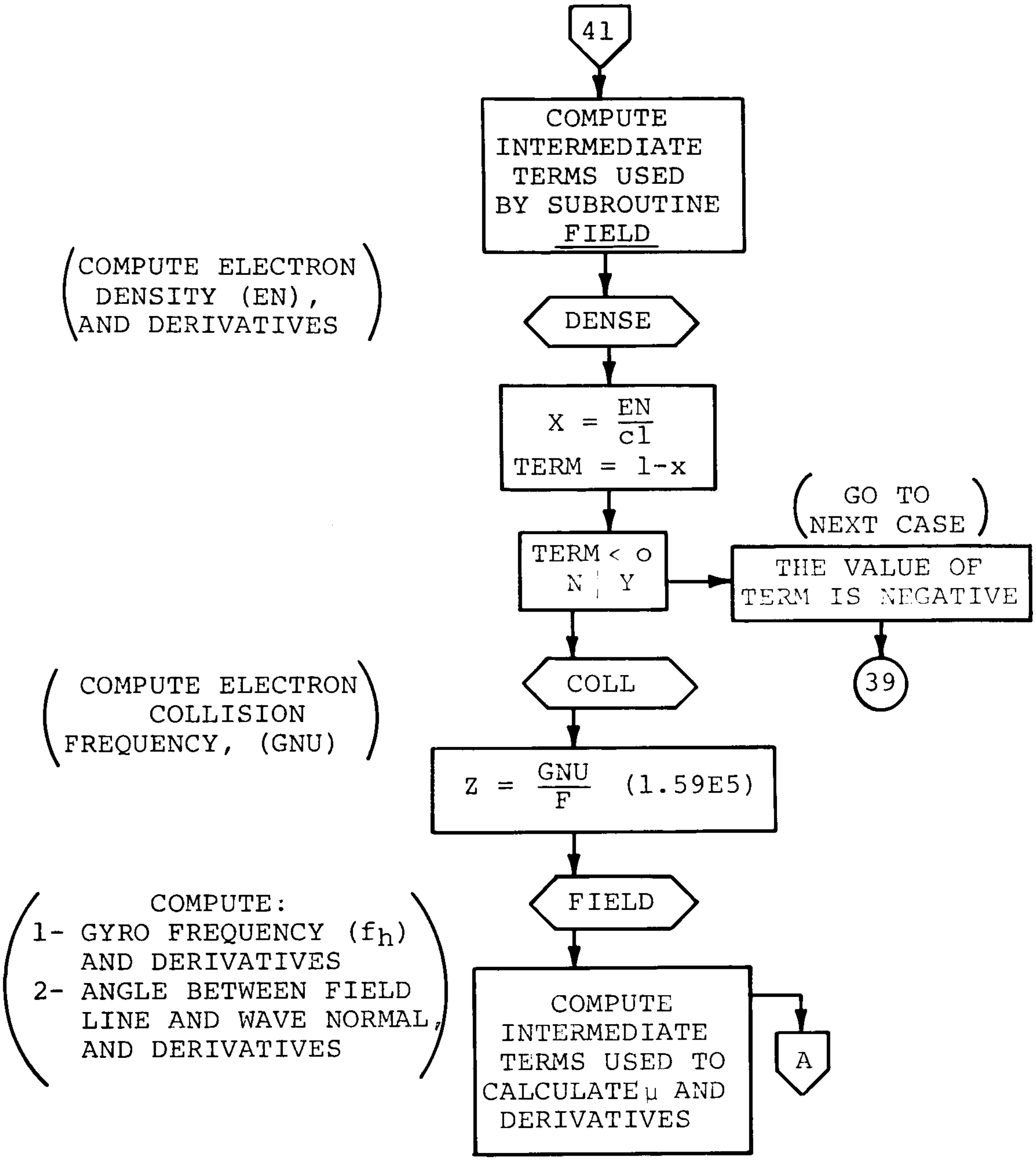


Figure 8C. - Flow Chart of Main Program

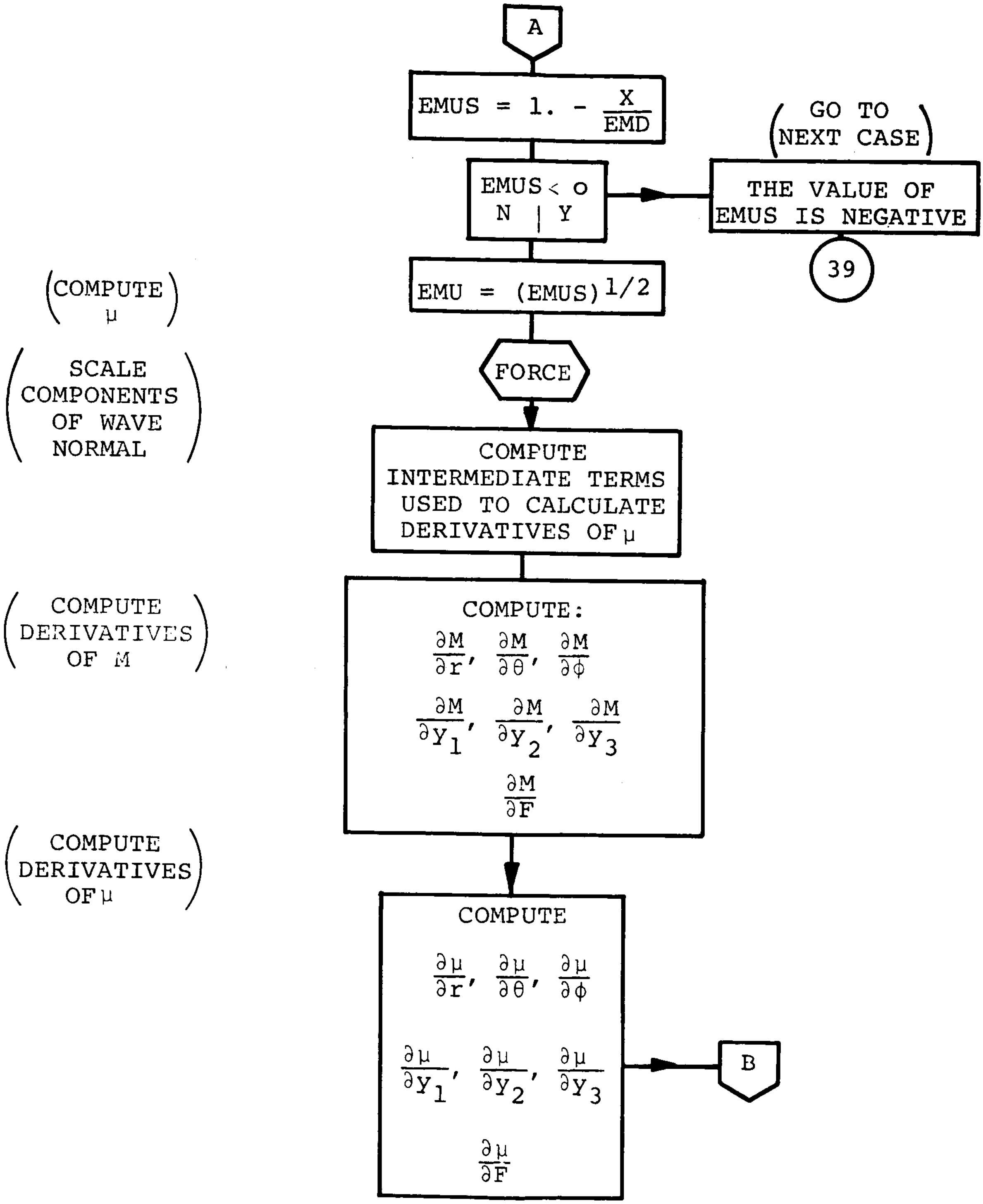


Figure 8D. - Flow Chart of Main Program

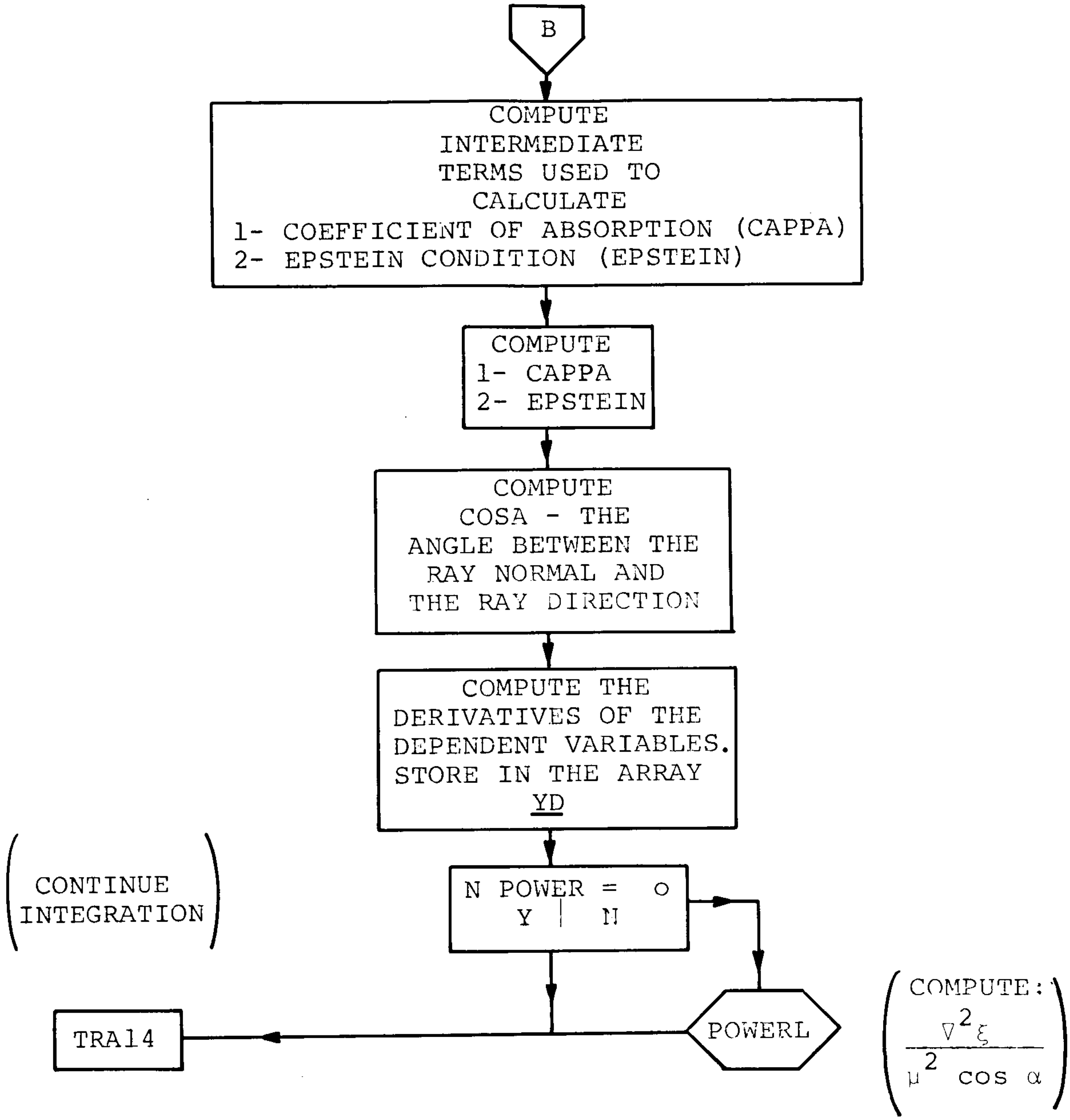


Figure 8E. - Flow Chart of Main Program

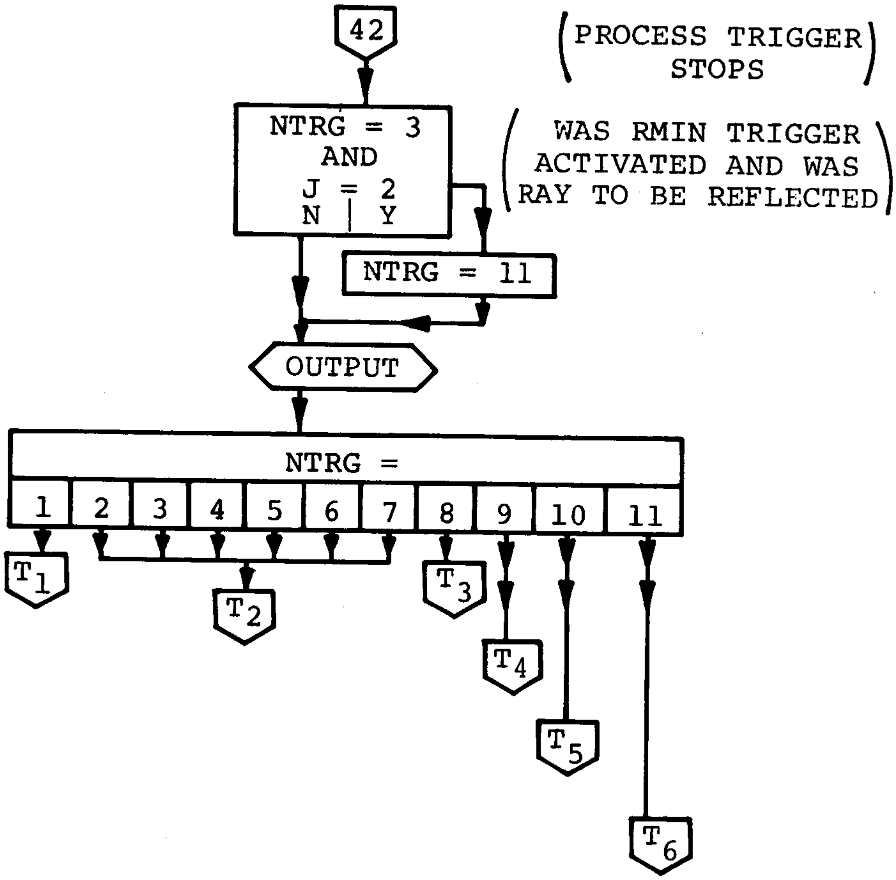


Figure 8F. - Flow Chart of Main Program

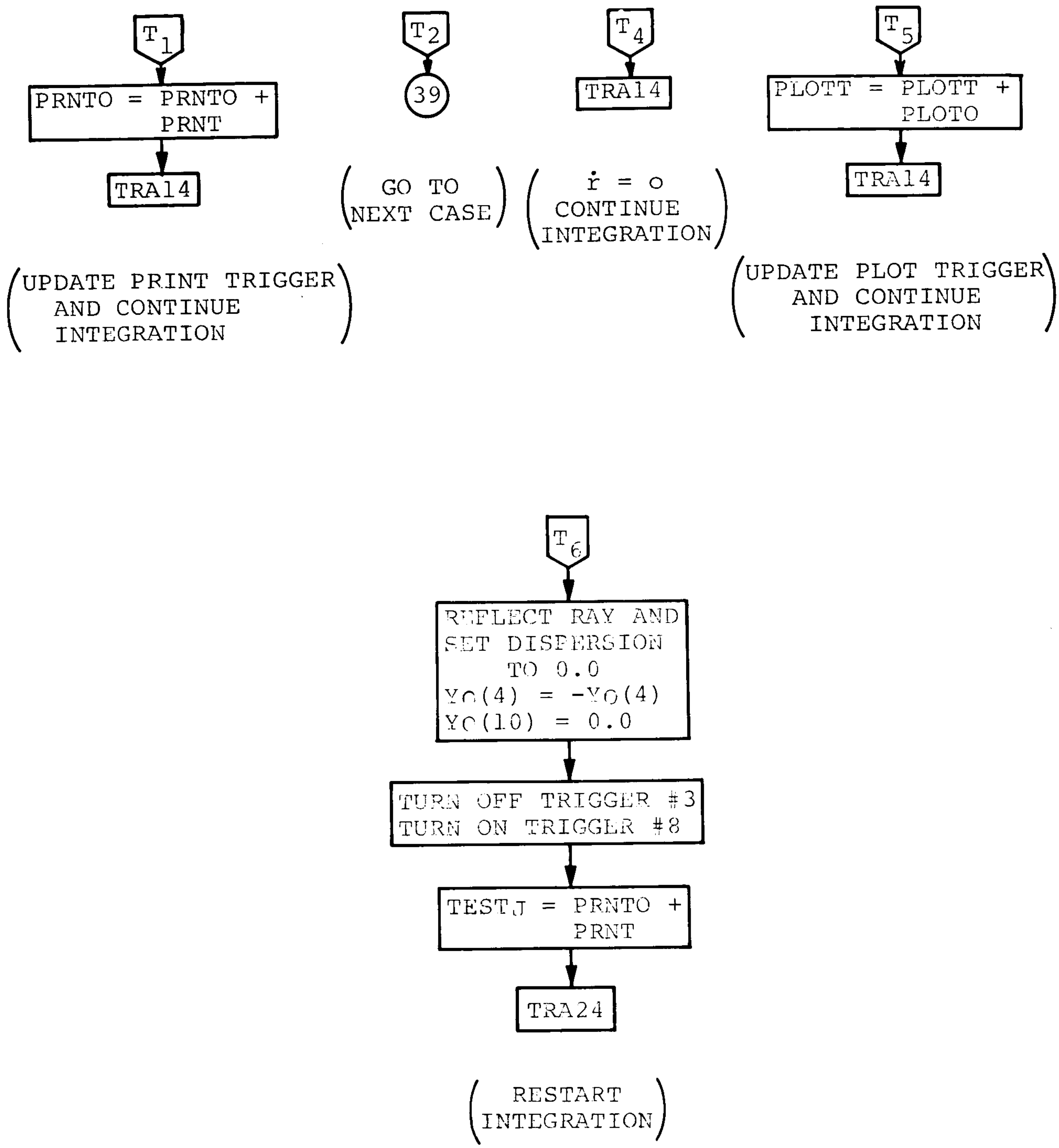


Figure 8G. - Flow Chart of Main Program

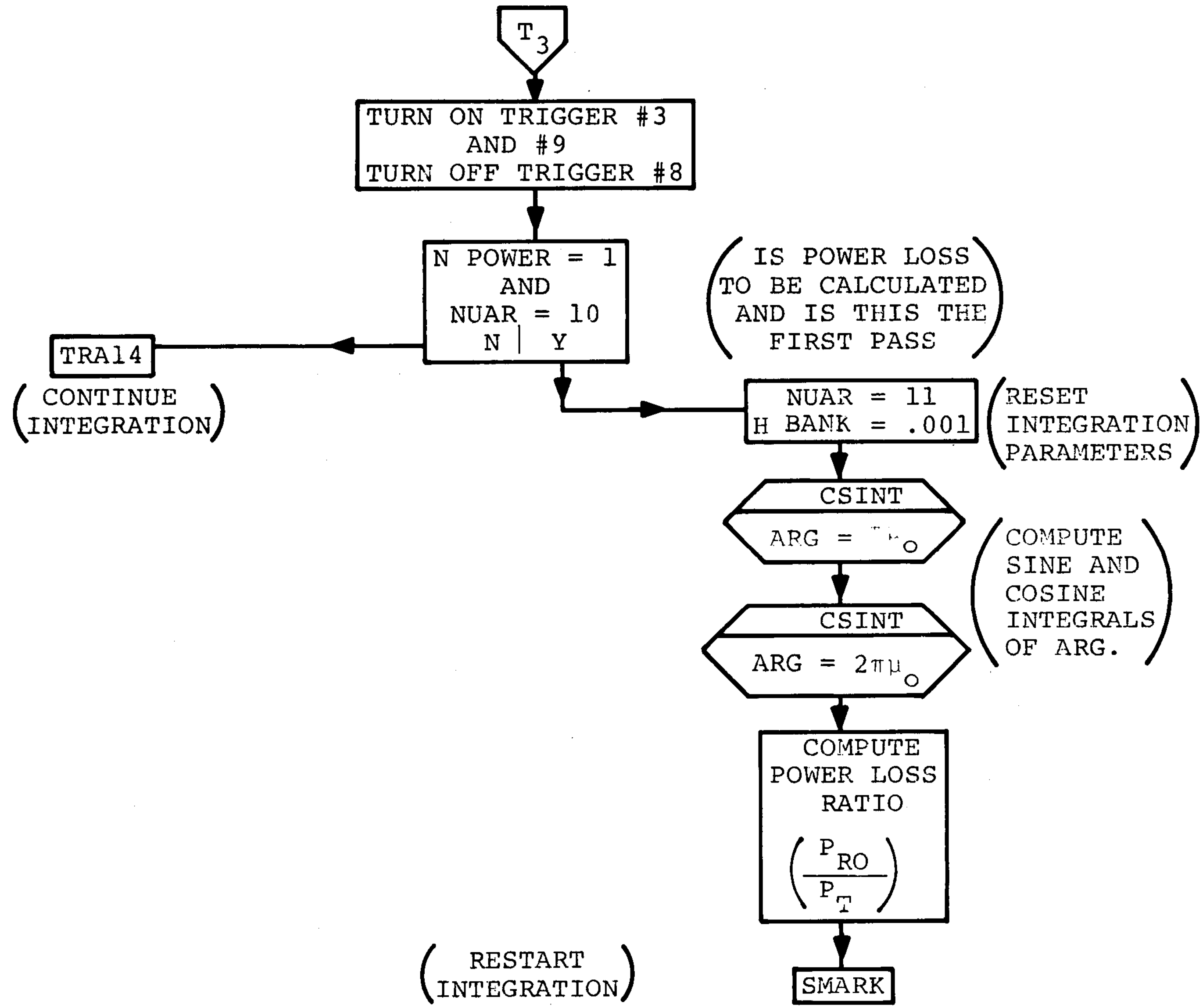


Figure 8H. - Flow Chart of Main Program

TABLE VI

ACTION TAKEN WITH REFERENCE TO RETURN INDICATOR

NRTN	
1	Return control to the integration routine.
2	Transfer control to DER1, the derivative box inclusive of any calculations which involve the independent variable.
3	Transfer control to DER2, the derivative box exclusive of any calculations which involve the independent variable. NOTE In this application, the independent variable is never used explicitly so for NRTN = 2 and NRTN = 3, control is transferred to DER2.
4	A trigger stop has occurred, process trigger stop.
5	An error has occurred during integration. The message ERROR RETURN FROM MARK will be printed and the program will stop.

Trigger stops are used to interrupt the integration routine at predetermined points. This program uses ten triggers. If a trigger stop occurs (i.e., NRTN = 4), the trigger indicator, NTRG, is set to an integer value from 1 to 10. The value assumed by NTRG corresponds to the trigger activated by the integration routine, MARK.

Table VII correlates the value of NTRG, the trigger activated and the sequence of actions taken.

TABLE VII

SEQUENCE OF ACTIONS TAKEN WITH REFERENCE TO TRIGGER INDICATOR

NTRG	
1	Print interval: call OUTPUT to print data, update trigger, return control to MARK.
2	The geocentric radius, r, has reached R_{max}: call OUTPUT to print data, if NPLOT $\geqslant$ 0 plot data, print end of case message, call INPUT to process next case.
3	The geocentric radius, r, has reached R_{min}: if reflection indicator, JTEST, does not equal two, the procedure is the same as for NTRG = 2, if JTEST = 2, the ray is reflected from a plane perpendicular to $\vec{r}$ and control is returned to the integration routine.
4	$\theta \geqslant \theta_{max}$: the procedure is the same as for NTRG = 2.
5	$\theta \leqslant \theta_{min}$: the procedure is the same as for NTRG = 2.
6	$\phi \geqslant \phi_{max}$: the procedure is the same as for NTRG = 2.
7	$\phi \leqslant \phi_{min}$: the procedure is the same as for NTRG = 2.
8	Phase path, h_p, has reached a value indicated by TESTJ: the stop on TESTJ has two functions. The first is to delay the start of the power loss calculation until the ray has traveled enough to be considered in the far field. It also turns on the trigger for a reflection stop when the ray has gone a specified distance past the reflection.

TABLE VII.— Concluded

SEQUENCE OF ACTIONS TAKEN WITH REFERENCE TO TRIGGER INDICATOR

NTRG	
9	$\dot{r} = 0$: call OUTPUT to print data, and store current values of r, θ, and ϕ in plotting arrays, print value of r, return control to MARK.
10	Plot interval: store current values of r, θ, and ϕ in plotting arrays, update trigger, return control to MARK.

Differential equations evaluated in the MAIN PROGRAM.- The following equations form a closed system for tracing the rays. The ray is described in terms of position in spherical coordinates with the origin at the center of the Earth and in terms of the components of the wave normal, Y_1, Y_2, Y_3 in the r, θ, ϕ directions, respectively.

#1 $$\dot{r} = \frac{1}{\mu^2}\left(Y_{1N} - \mu\frac{\partial\mu}{\partial Y_1}\right) \quad ; \; r(o) = r_o$$

#2 $$\dot{\theta} = \frac{1}{r\mu^2}\left(Y_{2N} - \mu\frac{\partial\mu}{\partial Y_2}\right) \quad ; \; \theta(o) = \theta_o$$

#3 $$\dot{\phi} = \frac{1}{r\mu^2\sin\theta}\left(Y_{3N} - \mu\frac{\partial\mu}{\partial Y_3}\right) \quad ; \; \phi(o) = \phi_o$$

#4 $$\dot{Y}_1 = \frac{1}{\mu}\frac{\partial\mu}{\partial r} + \dot{\theta}\,Y_2 + \dot{\phi}\,Y_3\sin\theta \quad ; \; Y_1(o) = Y_{10}$$

$$\#5 \qquad \dot{Y}_2 = \frac{1}{r}\left[\frac{1}{\mu}\frac{\partial\mu}{\partial\theta} - \dot{r}Y_2 + \dot{\phi}Y_3 r\cos\theta\right] \qquad ; \; Y_2(o) = Y_{20}$$

$$\#6 \qquad \dot{Y}_3 = \frac{1}{r\sin\theta}\left[\frac{1}{\mu}\frac{\partial\mu}{\partial\phi} - \dot{r}Y_3\sin\theta - \dot{\theta}Y_3 r\cos\theta\right] \; ; \; Y_3(o) = Y_{30}$$

where Y_{in} are components of the normalized Y-vector, i.e.,

$$\sum_{i=1}^{3} Y_{in}^2 = \mu^2$$

$\vec{Y}$ is normalized by subroutine FORCE. The symbols $\dot{r}$, $\dot{\theta}$, $\dot{\phi}$, $\dot{Y}_1$, $\dot{Y}_2$, $\dot{Y}_3$ are derivatives with respect to phase path length, h_p (the independent variable), in kilometers. The symbol μ is the phase refractive index.

The simplified Appleton-Hartree expression for the phase refractive index is used. It is given by

$$\mu^2 = 1 - \frac{X}{1 - M \pm \sqrt{M^2 + Y_L^2}}$$

and the collisions are neglected.

The appropriate algebraic sign ($\pm$) in the denominator is chosen according to the indicator supplied by the user via the required input D(17). The plus (+) sign refers to ordinary rays and the minus (-) sign refers to extra-ordinary rays.

$$X = \frac{e^2 N}{\epsilon_o m(2\pi f)^2} = \frac{N}{12400.f^2} = \frac{N}{C_1}$$

N = electron density in electrons per cc

f = frequency of propagation in megacycles per second

e = charge of an electron

m = mass of an electron

ε_o = permittivity of free space

$$C_1 = \frac{\epsilon_o m(2\pi f)^2}{e^2} = 12400.f^2$$

$$M = \frac{\frac{1}{2} Y_T^2}{1 - X}$$

$$Y_T = \frac{f_H \sin \psi}{f}$$

$$Y_L = \frac{f_H \cos \psi}{f}$$

f_H = gyrofrequency in megacycles per sec

ψ = angle between the magnetic field and the wave normal

The problem is now reduced to one of finding N, f_H and ψ and their derivatives with respect to r, θ, ϕ, Y_1, Y_2 and Y_3. The initial coordinates of the ray-position (r_o, θ_o, ϕ_o) and the initial ray direction (Y_{10}, Y_{20}, Y_{30}) and the wave-frequency, f, should be known. Thus, for a given electron density (N) and magnetic field (f_H and ψ), one can trace rays of any frequency from any point. This is subject to the constraint that $\mu^2 \geqslant 0$. The local values of electron density, $N(r, \theta, \phi)$, and the magnetic field, $f_H(r, \theta, \phi)$ and $\mu(r, \theta, \phi, Y_1, Y_2, Y_3)$ are derived from the respective models.

For Hamilton's equations, one must evaluate $\partial\mu/\partial r$, $\partial\mu/\partial\theta$, $\partial\mu/\partial\phi$, $\partial\mu/\partial Y_1$, $\partial\mu/\partial Y_2$ and $\partial\mu/\partial Y_3$.

$$\frac{\partial\mu}{\partial r} = \frac{1}{2\mu M_R} \cdot \left\{ -\frac{1}{C_1}\frac{\partial N}{\partial r} + \frac{N}{C_1 M_R}\left[-\frac{\partial M}{\partial r} \pm \frac{1}{R}\left(M\frac{\partial M}{\partial r} + \frac{Y_L^2}{f_H}\frac{\partial f_H}{\partial r} + \cos\psi \, \frac{f_H^2}{f^2}\frac{\partial \cos\psi}{\partial r} \right) \right] \right\}$$

$$\frac{\partial\mu}{\partial\theta} = \frac{1}{2\mu M_R} \cdot \left\{ -\frac{1}{C_1} \frac{\partial N}{\partial\theta} + \frac{N}{C_1 M_R} \left[-\frac{\partial M}{\partial\theta} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial\theta} + \frac{Y_L^2}{f_H} \frac{\partial f_H}{\partial\theta} \right.\right.\right.$$

$$\left.\left.\left. + \cos\psi \frac{f_H^2}{f^2} \frac{\partial\cos\psi}{\partial\theta} \right)\right]\right\}$$

$$\frac{\partial\mu}{\partial\phi} = \frac{1}{2\mu M_R} \cdot \left\{ -\frac{1}{C_1} \frac{\partial N}{\partial\phi} + \frac{N}{C_1 M_R} \left[-\frac{\partial M}{\partial\phi} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial\phi} + \frac{Y_L^2}{f_H} \frac{\partial f_H}{\partial\phi} \right.\right.\right.$$

$$\left.\left.\left. + \cos\psi \frac{f_H^2}{f^2} \frac{\partial\cos\psi}{\partial\phi} \right)\right]\right\}$$

$$\frac{\partial\mu}{\partial y_1} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[-\frac{\partial M}{\partial y_1} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_1} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial\cos\psi}{\partial Y_1} \right)\right]\right\}$$

$$\frac{\partial\mu}{\partial y_2} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[\frac{\partial M}{\partial y_2} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_2} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial\cos\psi}{\partial y_2} \right)\right]\right\}$$

$$\frac{\partial\mu}{\partial y_3} = \frac{1}{2\mu M_R^2} \left\{ \frac{N}{C_1} \left[-\frac{\partial M}{\partial y_3} \pm \frac{1}{R} \left(M \frac{\partial M}{\partial y_3} + \cos\psi \frac{f_H^2}{f^2} \frac{\partial\cos\psi}{\partial y_3} \right)\right]\right\}$$

$$\frac{\partial M}{\partial r} = \frac{1}{2f^2(1-x)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial r} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial r} \right.$$

$$\left. + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial r}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial \theta} = \frac{1}{2f^2(1-X)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial \theta} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial \theta} + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial \theta}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial \phi} = \frac{1}{2f^2(1-X)} \left\{ 2f_H \sin^2\psi \frac{\partial f_H}{\partial \phi} + f_H^2 \sin\psi \frac{\partial \sin\psi}{\partial \phi} + \frac{\frac{f_H^2}{C_1} \sin^2\psi \frac{\partial N}{\partial \phi}}{1 - X} \right\}$$

$$\frac{\partial M}{\partial Y_1} = \frac{1}{(1-X)} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_1}$$

$$\frac{\partial M}{\partial Y_2} = \frac{1}{1-X} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_2}$$

$$\frac{\partial M}{\partial Y_3} = \frac{1}{1-X} \frac{f_H^2}{f^2} \sin\psi \frac{\partial \sin\psi}{\partial Y_3}$$

$$\frac{\partial \mu}{\partial f} = \frac{X}{2\mu M_R^2} \left\{ -\frac{Y_T Y_L}{1-X} + \frac{1}{R} \left(M \frac{Y_T Y_L}{1-X} - Y_T Y_L \right) \right\}$$

where

$$R = \sqrt{M^2 + Y_L^2}$$

$$M_R = 1 - M \pm R$$

The derivatives of N are calculated in DENSE (subroutine).

The derivatives of ψ and f_H are calculated in FIELD (subroutine).

Other differential equations evaluated.- Group path length, ray path length, power loss due to absorption, doppler shift, and power loss along the ray's path are the other differential equations evaluated and are discussed as follows:

(1) Group Path Length

$$\dot{G}_L = 1 + \frac{f}{\mu}\frac{\partial \mu}{\partial f} \qquad G_L(o) = 0$$

G_L is measured in km

Group delay is determined by

$$G_D = \frac{1}{c} G_L$$

where

$c = 3.0 \times 10^5$ km/sec $\equiv$ velocity of light

(2) Ray Path Length

$$\dot{S} = \frac{1}{\mu \cos \alpha} \qquad S(o) = 0$$

S is measured in km

α is the angle between the wave normal and and the ray direction

(3) Power Loss Due To Absorption

$$\dot{D} = -2\frac{K}{\mu} D \qquad D(o) = 1.0$$

$$K = \frac{2\pi f k}{c}$$

where

D = power loss due to absorption

k = index of absorption

K = coefficient of absorption

$$k = \frac{BX}{2\mu(A^2 + B^2)} \qquad X = \frac{N e^2}{\epsilon_o m(2\pi f)^2}$$

$$A = 1 - \frac{\frac{1}{2}\frac{f_H^2}{f^2}\sin^2\psi(1-X)}{(1-X)^2 + Z^2} \pm \left\{\frac{1}{2}\left[U + (U^2+V^2)^{1/2}\right]\right\}^{1/2}$$

$$B = Z + \frac{\frac{1}{2} Z \frac{f_H^2}{f^2} \sin^2\psi}{(1-X)^2 + Z^2} \pm \frac{V}{2\left\{\frac{1}{2}\left[U + (U^2 + V^2)^{1/2}\right]\right\}^{1/2}}$$

$$U = \left[\frac{\frac{1}{2} y^2 \sin^2\psi(1-X)}{(1-X)^2 + Z^2}\right]^2 - \left[\frac{\frac{1}{2} Z y^2 \sin^2\psi}{(1-X)^2 + Z^2}\right]^2 + y^2 \cos\psi$$

$$V = 2\,\frac{\frac{1}{2} y^2 \sin^2\psi(1-X)}{(1-X)^2 + Z^2} \cdot \frac{\frac{1}{2} y^2 \sin^2\psi\, Z}{(1-X)^2 + Z^2}$$

where

$$y = \frac{f_H}{f}$$

$$Z = \frac{\nu}{2\pi f} \qquad \nu = \text{collision frequency in collisions per sec}$$

ν is given by the collision frequency model. The collision frequency model is described in subroutine COLL.

(4) Doppler Shift

$$\Delta f = -\frac{f}{c}\int_{r_o}^{r} \mu\cos\alpha\, ds\,; \qquad \Delta f(o) = 0$$

Δf is the Doppler-Shift in MHz

c is the velocity of light

f is the wave frequency om MHz

μ is the phase refractive index

(5) Power Loss Along the Path of the Ray

The total power loss in dB is:

$$10 \log_{10}\left\{ \frac{c^2}{4\pi f^2} \times \frac{P_{r_o}}{P_T} \times \frac{\mu_{Final}}{\mu_o}\ \mathrm{EXP}(E_1) \times \mathrm{EXP}(E_2) \right\}$$

$$E_1 = -\int_{s_t}^{s_L} \frac{\nabla^2 \xi}{\mu}\, ds$$

$$E_2 = -2\int_{s_o}^{s_1} \alpha_{ABS}\, ds$$

where

$$ds = \frac{dh_p}{\mu \cos \alpha}$$

s = ray path length

h_p = phase path length

$\frac{c^2}{4\pi f^2}$ = isotropic radiator aperture loss

$\frac{P_{ro}}{P_T}$ = near field loss due to refraction and inverse square law spreading

$$\mathrm{EXP}\left[-\int_{s_t}^{s_L} \frac{\nabla^2 \xi}{\mu}\, ds\right]$$ = far field loss due to refraction and inverse square law spreading

$$\mathrm{EXP}\left[-\int_{s_o}^{s_t} \alpha_{ABS}\, ds\right]$$ = power loss due to absorption

α_{ABS} is related to the absorption coefficient, K, of the wave by the expression

$$\alpha_{ABS} = K \cos \alpha \ .$$

Then the term

$$\mathrm{EXP}\left[-2\int_{s_o}^{s_t} \alpha_{ABS}\, ds\right]$$

is equivalent to D, the power loss due to absorption.

Power loss in the near field.- The power losses in the near field is calculated in MAIN. It is evaluated only once, when the ray has traveled far enough to be considered in the far field.

P_{RO}/P_T gives the power loss in the near field from s_o to s_t due to refraction and inverse square law spreading. The equation given below is for a dipole antenna.

r' and γ' are shown in the following Figure 9.

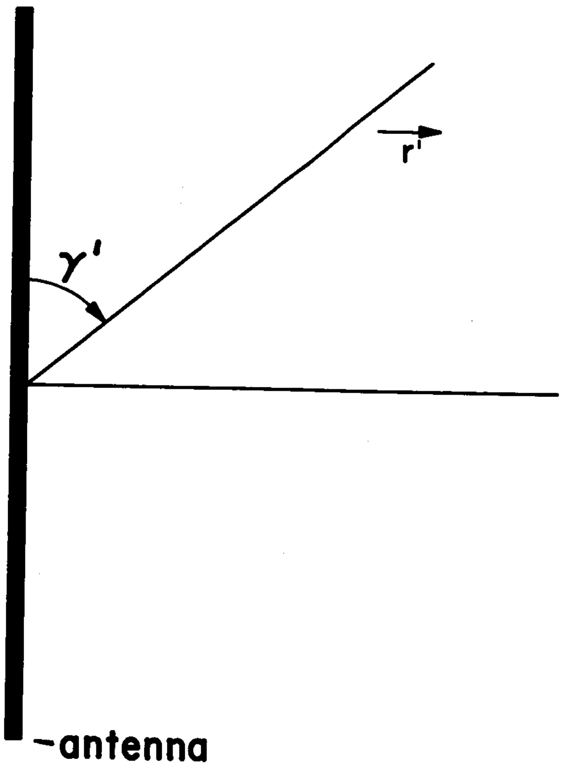


Figure 9.- Dipole antenna defined.

Let

$$C_i(P) = -\int_P^{\infty} \frac{\cos(x)}{x}\,dx$$

$$C_i(P) = \int_o^{P} \frac{\sin(x)}{x}\,dx$$

then

$$\frac{P_{RO}}{P_T} = \frac{\left[\dfrac{\cos\;(T\cos\gamma') - \cos\left(\frac{1}{2}T\right)}{\sin\gamma'}\right]^2}{2\pi(r')^2 A_1}$$

where $$T = \pi\mu_o$$

$$(r')^2 = r_o^2 + r^2 - 2r_o r\cos\gamma$$

$$\cos\gamma = \sin(\theta_o)\sin(\theta)\cos(\phi_o - \phi) - \cos(\theta_o)\cos(\theta)$$

$$\gamma' = \pi - \cos^{-1}\left[\frac{(r')^2 + (r_o^2) - r^2}{2r'r_o}\right]$$

$$A_1 = .5772 + \ln(T) - C_i(T)$$

$$+ \frac{1}{2}\sin(T)\left[S_i(2T) - 2S_i(T)\right]$$

$$+ \frac{1}{2}\cos(T)\left[C_i(2T) - 2C_i(T)\right]$$

$$+ \frac{1}{2}\cos(T)\left[.5772 + \ln(\tfrac{1}{2}T)\right]$$

Program Notes.- The program variable PROPT is actually

$$\frac{c^2}{4\pi f^2 \mu_o \times 10^{12}} \quad x \quad \frac{P_{ro}}{P_T}$$

where

c = the velocity of light in km/sec

$= 3 \times 10^5$ km/sec

Power loss in the far field.- The term

$$\frac{\mu_{Final}}{\mu_o} \int_{s_t}^{s_r} \frac{\sqrt{2}\,\xi}{\mu}\, ds$$

where ξ is the eikonal function which has the property that the surface ξ = constant is the geometrical wave-front and gives the power loss in the far field due to refraction and inverse square spreading. These are field losses calculated in POWERL routine but integrated under control of the main program.

Polarization Term.- The expression $R = E_{\bar{x}}/E_{\bar{y}}$, a complex number, is the polarization term. $E_{\bar{x}}$ and $E_{\bar{y}}$ are the components of the electric vector of the wave along axes $(\bar{x},\bar{y})$ in the wave front, $\bar{y}$ being in and $\bar{x}$ perpendicular to the plane containing the magnetic field of the Earth.

$$|R| = \text{modulus of } R = \frac{1}{Y_L}\left[\frac{\frac{1}{4}Y_T^4 + A \pm Y_T^2 A^{1/2} \cos\left(\frac{\theta}{2}\right)}{d}\right]^{1/2}$$

$$\Phi = \text{argument of } R = \tan^{-1}\left\{\frac{-\frac{1}{2}(1-X)Y_T^2 \pm A^{1/2}\left[\cos\frac{\theta}{2}(1-X) - Z\sin\frac{\theta}{2}\right]}{\frac{1}{2}ZY_T^2 \pm A^{1/2}\left[\sin\frac{\theta}{2}(1-X) + Z\cos\frac{\theta}{2}\right]}\right\}$$

$$d = (1-X)^2 + Z^2$$

$$A = \left\{\left[\frac{1}{4}Y_T^4 + Y_L^2\, d\right]^2 + \left[2\,Z\,Y_L^2\,(1-X)\right]^2\right\}^{1/2}$$

where

$$\theta = \tan^{-1}\left\{\frac{-2(1-X)Z\,Y_L^2}{\frac{1}{4}Y_T^4 + Y_L^2\, d}\right\}$$

Evaluation of the polarization term is described under subroutine POLAR.

Dictionary of Major FORTRAN Names.- Table VIII contains a dictionary of major FORTRAN names for the MAIN program.

TABLE VIII

FORTRAN NAME	DEFINITION
PRNTO	Value of PRINT trigger
PLOTT	Value of PLOT trigger
MORDGR	Order of differences carried in integration routine
MUFLAG	Pass indicator subroutine POWERL. Equals zero for the first pass and 1 for the rest of the run
DMDR	$\frac{\partial M}{\partial r}$
DMDT	$\frac{\partial M}{\partial \theta}$
DMDP	$\frac{\partial M}{\partial \phi}$
DMDY1	$\frac{\partial M}{\partial Y_1}$
DMDY2	$\frac{\partial M}{\partial Y_2}$
DMDY3	$\frac{\partial M}{\partial Y_3}$
DMDF	$\frac{\partial M}{\partial F}$
DMUDR	$\frac{\partial \mu}{\partial r}$
DMUDT	$\frac{\partial \mu}{\partial \theta}$
DMUDP	$\frac{\partial \mu}{\partial \phi}$
DMUDY1	$\frac{\partial \mu}{\partial Y_1}$
DMUDY2	$\frac{\partial \mu}{\partial Y_2}$
DMUDY3	$\frac{\partial \mu}{\partial Y_3}$

TABLE VIII.- Concluded

FORTRAN NAME	DEFINITION
DMUDF	$\frac{\partial \mu}{\partial f}$
CAPPA	K, absorption coefficient
EPSTIN	Epstein condition
DMDSI	$\frac{\partial M}{\partial \psi}$
DMUDSI	$\frac{\partial \mu}{\partial \psi}$
YD	Array of values of differential equations
DENØM	A_1
CØSPSI	cøs γ
RP	r' — see near field power losses
PSI	γ'
PRØPT	$\frac{P_{ro}}{P_T}$

Subroutine POWERL

Description.- POWERL computes the power loss in the far field due to refraction and inverse square law spreading.

POWERL evaluates

$$\dot{P}_F = \frac{\nabla^2 \zeta}{\mu^2 \cos\alpha}$$

where ζ is the eikonal function which has the property that the surface ζ = constant is the geometrical wave front.

Derivation of ∇_ζ^2

$$\nabla\zeta = n\frac{d\bar{r}'}{ds} = \mu\left(\frac{\partial r'}{\partial s}\ \hat{r}'\right)$$

$$= \mu\left(\frac{\partial r'}{\partial r}\dot{r} + \frac{\partial r'}{\partial \theta}\dot{\theta} + \frac{\partial r'}{\partial \phi}\ \dot{\phi}\right)\frac{\partial h_p}{\partial s}\ \hat{r}' = \mu\,\dot{r}'\,\hat{r}'$$

where

$$\dot{r}' = \frac{1}{\sqrt{\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2}}\left\{\frac{\partial r'}{\partial r}\left(y_1 - \mu\frac{\partial\mu}{\partial y_1}\right) + \frac{\partial r'}{\partial\theta}\ \frac{1}{r}\left(y_2 - \mu\frac{\partial\mu}{\partial y_2}\right)\right.$$

$$\left. + \frac{\partial r'}{\partial\phi}\ \frac{1}{r\sin\theta}\left(y_3 - \mu\frac{\partial\mu}{\partial y_3}\right)\right\}$$

$$\nabla^2\zeta = \operatorname{div}\left(\mu\frac{\partial\bar{r}'}{\partial s}\right) = \frac{1}{(r')^2}\ \frac{\partial}{\partial r'}\ (\mu(r')^2\dot{r}')$$

where

$$\frac{1}{(r')^2}\ \frac{\partial}{\partial r'}\ (\mu(r')^2\dot{r}') = \left(\frac{2\mu}{r'} + \frac{\partial\mu}{\partial r'}\right)\dot{r}' - \frac{\mu\dot{r}'\left(\mu\frac{\partial\mu}{\partial r'} + \frac{\partial\mu}{\partial\psi}\ \frac{\partial^2\mu}{\partial r'\partial\psi}\right)}{\left(\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2\right)}$$

$$- \frac{\mu}{\left(\mu^2 + \left(\frac{\partial\mu}{\partial\psi}\right)^2\right)^{1/2}}\left\{\frac{\partial r'}{\partial r}\left(\frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_1} + \mu\ \frac{\partial^2\mu}{\partial r'\partial y_1}\right)\right.$$

$$+ \frac{1}{r}\ \frac{\partial r'}{\partial\theta}\left[\frac{1}{r}\ \frac{\partial r}{\partial r'}\left(y_2 - \mu\frac{\partial\mu}{\partial y_2}\right) + \left(\frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_2} + \mu\frac{\partial^2\mu}{\partial r'\partial y_2}\right)\right]$$

$$+ \frac{1}{r\sin\theta}\ \frac{\partial r'}{\partial\phi}\left[\left(\frac{1}{r}\ \frac{\partial r}{\partial r'} + \frac{\cos\theta}{\sin\theta}\ \frac{\partial\theta}{\partial r'}\right)\left(y_3 - \mu\frac{\partial\mu}{\partial y_3}\right)\right.$$

$$\left.\left. + \frac{\partial\mu}{\partial r'}\ \frac{\partial\mu}{\partial y_3} + \mu\ \frac{\partial^2\mu}{\partial r'\partial y_3}\right]\right\}$$

The derivatives of r' with respect to r, θ, φ are:

$$\frac{\partial r'}{\partial r} = \frac{1}{r'}\left[r - r_o\left(\sin\theta \sin\theta_o \cos(\phi-\phi_o) + \cos\theta \cos\theta_o\right)\right]$$

$$\frac{\partial r'}{\partial \theta} = \frac{rr_o}{r'}\left[\cos\theta_o \sin\theta - \sin\theta_o \cos\theta \cos(\phi-\phi_o)\right]$$

$$\frac{\partial r'}{\partial \phi} = \frac{rr_o}{r'} \sin\theta \sin\theta_o \sin(\phi-\phi_o)$$

To find the derivatives of r, θ, φ with respect to r', we differentiate the equations defining r', θ', φ' with respect to r'. In general, we have

$$\frac{1}{2}\frac{\partial}{\partial r'}(r')^2 = r\frac{\partial r}{\partial r'} - r_o\frac{\partial r}{\partial r'}\Big(\sin\theta \sin\theta_o \cos(\phi-\phi_o)$$

$$+ \cos\theta \cos\theta_o\Big) - rr_o\Big(\cos\theta \sin\theta_o \cos(\phi-\phi_o)\frac{\partial\theta}{\partial r'}$$

$$- \sin\theta \cos\theta_o \frac{\partial\theta}{\partial r'} - \sin\theta \sin\theta_o \sin(\phi-\phi_o)\frac{\partial\phi}{\partial r'}\Big)$$

$$\frac{\partial}{\partial r'}(r'\cos\theta') = \cos\theta\frac{\partial r}{\partial r'} - r\sin\theta\frac{\partial\theta}{\partial r'}$$

$$\frac{\partial}{\partial r'}(r'\sin\theta'\cos\phi') = \sin\theta\cos\phi\frac{\partial r}{\partial r'} + r\cos\theta\cos\phi\frac{\partial\theta}{\partial r'}$$

$$- r\sin\theta\sin\phi\frac{\partial\phi}{\partial r'}$$

We then solve these three simultaneous equations for

$$\frac{\partial r}{\partial r'}, \quad \frac{\partial\theta}{\partial r'}, \text{ and } \frac{\partial\phi}{\partial r'}$$

Now we must find the derivatives of μ with respect to the r, θ, ϕ system. The first derivatives of μ are given in MAIN PROGRAM. It remains to find the second derivatives.

$$\frac{\partial^2 \mu}{\partial \psi \partial r} = -\frac{1}{\mu} \frac{\partial \mu}{\partial \psi} \frac{\partial \mu}{\partial r} - \frac{1}{A} \frac{\partial \mu}{\partial r} \frac{\partial A}{\partial \psi} + \frac{N}{2\mu C_1 A^2} \Bigg[- \frac{\partial^2 M}{\partial \psi \partial r}$$

$$- \frac{1}{B} \frac{\partial B}{\partial \psi} \frac{\partial B}{\partial r} + \frac{1}{B} \Bigg(\frac{\partial M}{\partial r} \frac{\partial M}{\partial \psi} + M \frac{\partial^2 M}{\partial \psi \partial r}$$

$$- 2 \frac{f_H}{f^2} \cos\psi \sin\psi \frac{\partial f_H}{\partial r} - \frac{f_H^2}{f^2} \sin\psi \frac{\partial \cos\psi}{\partial r}$$

$$+ \frac{f_H^2}{f^2} \frac{\cos^2\psi}{\sin\psi} \frac{\partial \cos\psi}{\partial r} \Bigg) \Bigg] - \frac{N}{2\mu C_1 A^3} \frac{\partial A}{\partial r} \frac{\partial A}{\partial \psi}$$

$$\frac{\partial^2 \mu}{\partial \psi \partial \theta} = -\frac{1}{\mu} \frac{\partial \mu}{\partial \psi} \frac{\partial \mu}{\partial \theta} - \frac{1}{A} \frac{\partial \mu}{\partial \theta} \frac{\partial A}{\partial \psi} + \frac{N}{2\mu C_1 A^2} \Bigg[- \frac{\partial^2 M}{\partial \psi \partial \theta}$$

$$- \frac{1}{B} \frac{\partial B}{\partial \theta} \frac{\partial B}{\partial \psi} + \frac{1}{B} \Bigg(\frac{\partial M}{\partial \psi} \frac{\partial M}{\partial \theta} + M \frac{\partial^2 M}{\partial \psi \partial \theta}$$

$$- 2 \frac{f_H}{f^2} \cos\psi \sin\psi \frac{\partial f_H}{\partial \theta} - \frac{f_H^2}{f^2} \sin\psi \frac{\partial \cos\psi}{\partial \theta}$$

$$+ \frac{f_H^2}{f^2} \frac{\cos^2\psi}{\sin\psi} \frac{\partial \cos\psi}{\partial \theta} \Bigg) \Bigg] - \frac{N}{2\mu C_1 A^3} \frac{\partial A}{\partial \theta} \frac{\partial A}{\partial \psi}$$

$$\frac{\partial^2 \mu}{\partial\psi\partial\phi} = -\frac{1}{\mu}\frac{\partial\mu}{\partial\psi}\frac{\partial\mu}{\partial\phi} - \frac{1}{A}\frac{\partial\mu}{\partial\phi}\frac{\partial A}{\partial\psi} + \frac{N}{2\mu C_1 A^2}\Bigg[-\frac{\partial^2 M}{\partial\psi\partial\phi}$$

$$-\frac{1}{B}\frac{\partial B}{\partial\phi}\frac{\partial B}{\partial\psi} + \frac{1}{B}\left(\frac{\partial M}{\partial\psi}\frac{\partial M}{\partial\phi} + M\frac{\partial^2 M}{\partial\psi\partial\phi}\right.$$

$$-2\frac{f_H}{f^2}\cos\psi\sin\psi\frac{\partial f_H}{\partial\phi} - \frac{f_H^2}{f^2}\sin\psi\frac{\partial\cos\psi}{\partial\phi}$$

$$\left.+\frac{f_H^2}{f^2}\frac{\cos^2\psi}{\sin\psi}\frac{\partial\cos\psi}{\partial\phi}\right)\Bigg] - \frac{N}{2\mu C_1 A^3}\frac{\partial A}{\partial\phi}\frac{\partial A}{\partial\psi}$$

$$\frac{\partial^2\mu}{\partial y_1\partial r} = \frac{1}{2\mu}\Bigg[\frac{1}{A^2C_1}\left(\frac{\partial A}{\partial y_1}\frac{\partial N}{\partial r} - \frac{2N}{A}\frac{\partial A}{\partial r}\right) + \frac{N}{A^2C_1}\frac{\partial^2 A}{\partial y_1\partial r}$$

$$-2\frac{\partial\mu}{\partial r}\frac{\partial\mu}{\partial y_1}\Bigg]$$

$$\frac{\partial^2\mu}{\partial y_2\partial\theta} = \frac{1}{2\mu}\Bigg[\frac{1}{A^2C_1}\frac{\partial A}{\partial y_2}\left(\frac{\partial N}{\partial\theta} - \frac{2N}{A}\frac{\partial A}{\partial\theta}\right) + \frac{N}{A^2C_1}\frac{\partial^2 A}{\partial y_2\partial\theta}$$

$$-2\frac{\partial\mu}{\partial\theta}\frac{\partial\mu}{\partial y_2}\Bigg]$$

$$\frac{\partial^2\mu}{\partial y_3\partial\phi} = \frac{1}{2\mu}\Bigg[\frac{1}{A^2C_1}\frac{\partial A}{\partial y_3}\left(\frac{\partial N}{\partial\phi} - \frac{2N}{A}\frac{\partial A}{\partial\phi}\right) + \frac{N}{A^2C_1}\frac{\partial^2 A}{\partial y_3\partial\phi}$$

$$-2\frac{\partial\mu}{\partial\phi}\frac{\partial\mu}{\partial y_3}\Bigg]$$

where $$A = 1 - M \pm \sqrt{M^2 + \frac{f_H^2}{f^2} \cos^2 \psi}$$

$$B = \sqrt{M^2 + \frac{f_H^2}{f^2} \cos^2 \psi}$$

$$M = \frac{1}{2} \frac{f_H^2}{f^2} \frac{\sin^2 \psi}{C}$$

and $$C = 1 - \frac{N}{C_1}$$

$$\frac{\partial^2 M}{\partial \psi \partial r} = \frac{1}{2f^2} \frac{1}{\left(1 - \frac{N}{C_1}\right)} \left\{ 4 f_H \sin\psi \cos\psi \frac{\partial f_H}{\partial r} + 2 f_H^2 \cos\psi \frac{\partial \sin\psi}{\partial r} \right.$$

$$\left. + 2 f_H^2 \sin\psi \frac{\partial \cos\psi}{\partial r} + \frac{2 f_H^2 \sin\psi \cos\psi \frac{\partial N}{\partial r}}{\left(C_1 \left[1 - \frac{N}{C_1} \right] \right)} \right\}$$

$$\frac{\partial^2 M}{\partial \psi \partial \theta} = \frac{1}{2f^2} \frac{1}{\left(1 - \frac{N}{C_1}\right)} \left\{ 4 f_H \sin\psi \cos\psi \frac{\partial f_H}{\partial \theta} + 2 f_H^2 \cos\psi \frac{\partial \sin\psi}{\partial \theta} \right.$$

$$\left. + 2 f_H^2 \sin\psi \frac{\partial \cos\psi}{\partial \theta} + \frac{2 f_H^2 \sin\psi \cos\psi \frac{\partial N}{\partial \theta}}{\left(C_1 \left[1 - \frac{N}{C_1} \right] \right)} \right\}$$

$$\frac{\partial^2 M}{\partial\psi\partial\phi} = \frac{1}{2f^2}\ \frac{1}{\left(1 - \frac{N}{C_1}\right)} \left\{ 4\, f_H \sin\psi \cos\psi \frac{\partial f_H}{\partial\phi} + 2 f_H^2 \cos\psi \frac{\partial \sin\psi}{\partial\phi} \right.$$

$$\left. + 2\, f_H^2 \sin\psi \frac{\partial \cos\psi}{\partial\phi} + \frac{2\, f_H^2 \sin\psi \cos\psi \frac{\partial N}{\partial\phi}}{\left(C_1\left[1 - \frac{N}{C_1}\right]\right)} \right\}$$

$$\frac{\partial^2 M}{\partial r\partial y_1} = \frac{1}{f^2 C} \left\{ 2 f_H \sin\psi \frac{\partial \sin\psi}{\partial y_1}\ \frac{\partial f_H}{\partial r} + f_H^2\ \frac{\partial \sin\psi}{\partial r}\ \frac{\partial \sin\psi}{\partial y_1} \right.$$

$$\left. + f_H^2 \sin\psi \frac{\partial^2 \sin\psi}{\partial r\partial y_1} + \frac{f_H^2}{CC_1} \sin\psi\ \frac{\partial \sin\psi}{\partial y_1}\ \frac{\partial N}{\partial r} \right\}$$

$$\frac{\partial^2 M}{\partial\theta\partial y_2} = \frac{1}{f^2 C} \left\{ 2 f_H \sin\psi \frac{\partial \sin\psi}{\partial y_2}\ \frac{\partial f_H}{\partial\theta} + f_H^2\ \frac{\partial \sin\psi}{\partial y_2}\ \frac{\partial \sin\psi}{\partial\theta} \right.$$

$$\left. + f_H^2 \sin\psi\ \frac{\partial^2 \sin\psi}{\partial\theta\partial y_2} + \frac{f_H^2}{CC_1}\ \sin\psi\ \frac{\partial \sin\psi}{\partial y_2}\ \frac{\partial N}{\partial\theta} \right\}$$

$$\frac{\partial^2 M}{\partial\phi\partial y_3} = \frac{1}{f^2 C} \left\{ 2 f_H \sin\psi\ \frac{\partial \sin\psi}{\partial y_3}\ \frac{\partial f_H}{\partial\phi} + f_H^2\ \frac{\partial \sin\psi}{\partial\phi}\ \frac{\partial \sin\psi}{\partial y_3} \right.$$

$$\left. + f_H^2 \sin\psi\ \frac{\partial^2 \sin\psi}{\partial\phi\partial y_3} + \frac{f_H^2}{CC_1}\ \sin\psi\ \frac{\partial \sin\psi}{\partial y_3}\ \frac{\partial N}{\partial\phi} \right\}$$

$$\frac{\partial^2 A}{\partial r \partial y_1} = - \frac{\partial^2 M}{\partial r \partial y_1} \mp \frac{1}{B^3} \left(M \frac{\partial M}{\partial r} + \frac{f_H}{f^2} \cos\psi \left[\cos\psi \frac{\partial f_H}{\partial r} \right.\right.$$

$$\left.\left. + f_H \frac{\partial \cos\psi}{\partial r} \right] \right) \left(M \frac{\partial M}{\partial y_1} + \frac{f_H^2}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_1} \right)$$

$$\pm \frac{1}{B} \left\{ \frac{\partial M}{\partial r} \frac{\partial M}{\partial y_1} + M \frac{\partial^2 M}{\partial r \partial y_1} + \frac{2 f_H}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_1} \frac{\partial f_H}{\partial r} \right.$$

$$\left. + \frac{f_H^2}{f^2} \left(\frac{\partial \cos\psi}{\partial r} \frac{\partial \cos\psi}{\partial y_1} + \cos\psi \frac{\partial^2 \cos\psi}{\partial r \partial y_1} \right) \right\}$$

$$\frac{\partial^2 A}{\partial \theta \partial y_2} = - \frac{\partial^2 M}{\partial \theta \partial y_2} \mp \frac{1}{B^3} \left(M \frac{\partial M}{\partial \theta} + \frac{f_H}{f^2} \cos\psi \left[\cos\psi \frac{\partial f_H}{\partial \theta} \right.\right.$$

$$\left.\left. + f_H \frac{\partial \cos\psi}{\partial \theta} \right] \right) \left(M \frac{\partial M}{\partial y_2} + \frac{f_H^2}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_2} \right)$$

$$\pm \frac{1}{B} \left\{ \frac{\partial M}{\partial \theta} \frac{\partial M}{\partial y_2} + M \frac{\partial^2 M}{\partial \theta \partial y_2} + \frac{2 f_H}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_2} \frac{\partial f_H}{\partial \theta} \right.$$

$$\left. + \frac{f_H^2}{f^2} \left(\frac{\partial \cos\psi}{\partial \theta} \frac{\partial \cos\psi}{\partial y_2} + \cos\psi \frac{\partial^2 \cos\psi}{\partial \theta \partial y_2} \right) \right\}$$

$$\frac{\partial^2 A}{\partial\phi\partial y_3} = - \frac{\partial^2 M}{\partial\phi\partial y_3} \mp \frac{1}{B^3} \left(M \frac{\partial M}{\partial\phi} + \frac{f_H}{f^2} \cos\psi \left[\cos\psi \frac{\partial f_H}{\partial\phi} \right.\right.$$

$$\left.\left. + f_H \frac{\partial \cos\psi}{\partial\phi} \right] \right) \left(M \frac{\partial M}{\partial y_3} + \frac{f_H^2}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_3} \right)$$

$$\pm \frac{1}{B} \left\{ \frac{\partial M}{\partial\phi} \frac{\partial M}{\partial y_3} + M \frac{\partial^2 M}{\partial\phi\partial y_3} + \frac{2f_H}{f^2} \cos\psi \frac{\partial \cos\psi}{\partial y_3} \right.$$

$$\left. + \frac{f_H^2}{f^2} \left(\frac{\partial \cos\psi}{\partial\phi} \frac{\partial \cos\psi}{\partial y_3} + \cos\psi \frac{\partial^2 \cos\psi}{\partial\phi\partial y_3} \right) \right\}$$

The derivatives of f_H, cos ψ, and sin ψ depend on the particular magnetic field model used.

The power loss as computed above (and ray-tracing in general) is valid only when the following conditions are fulfilled:

$$\frac{1}{k\mu} \frac{\nabla\mu}{\mu} << 1 \text{ where } k = \frac{2\pi}{\lambda}$$

and

$$\frac{1}{k\mu} \frac{\nabla PL}{PL} << 1$$

These conditions are violated in rapidly varying media or when a caustic is encountered. Figure 10 is a flow chart of the subroutine POWERL.

Dictionary of major FORTRAN names.-Table IX contains a dictionary of major FORTRAN names, subroutine POWERL.

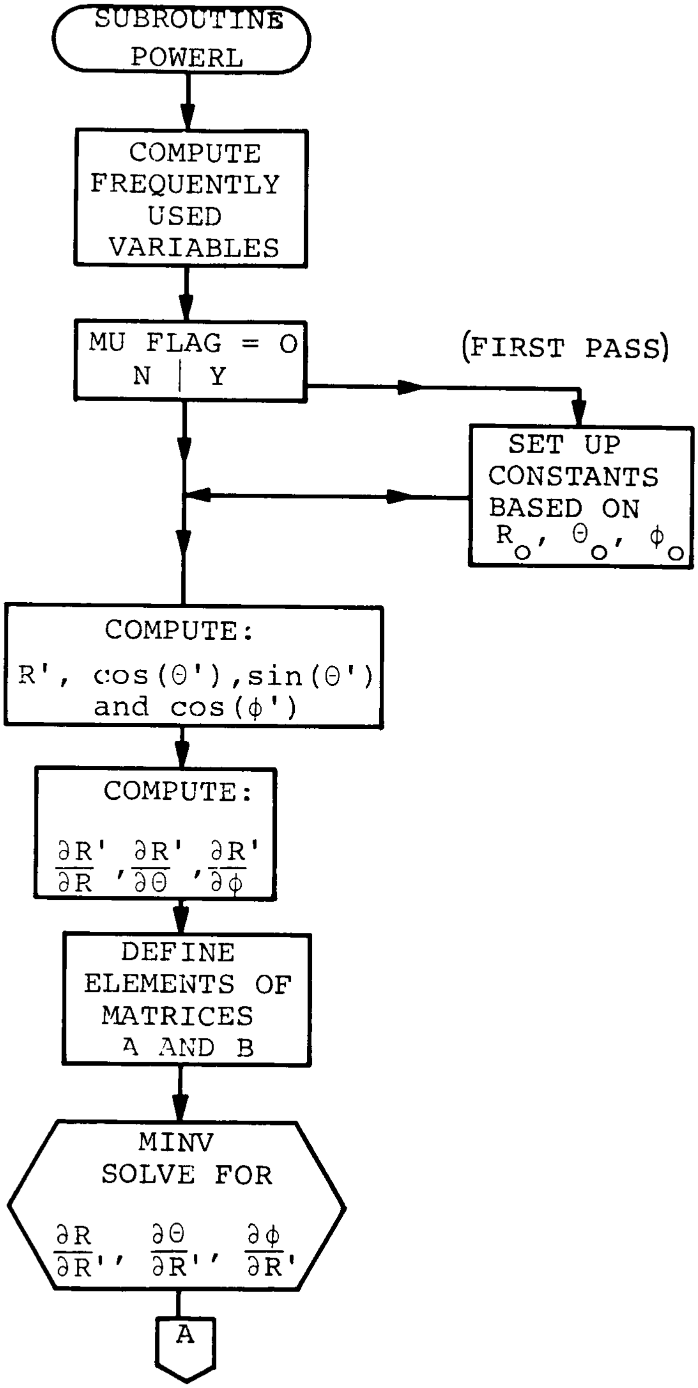


Figure 10A. - Flow Chart of Subroutine POWERL

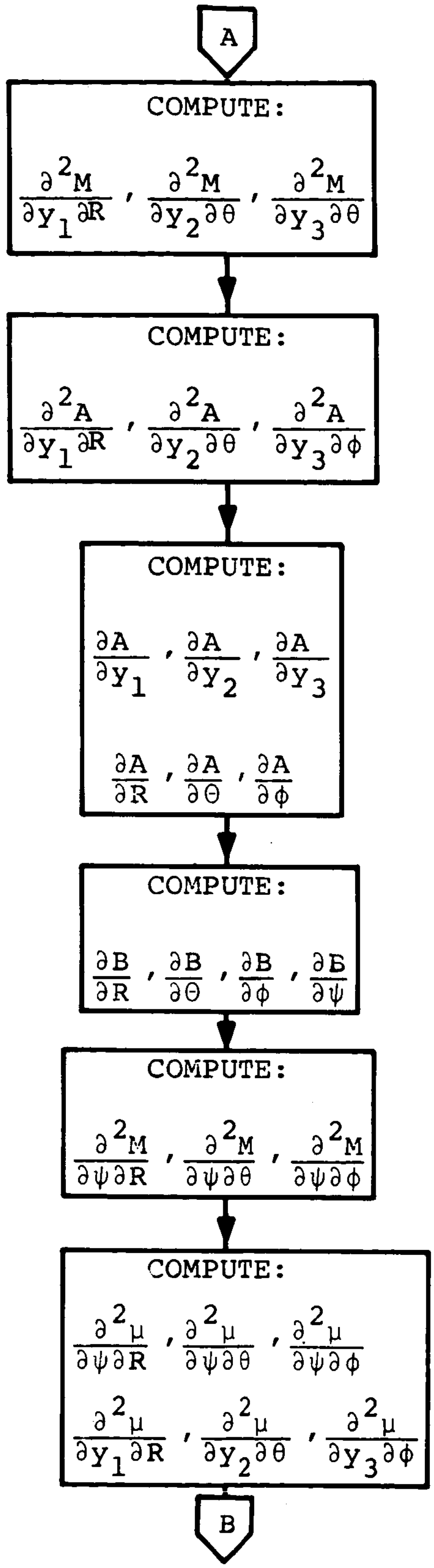


Figure 10B. - Flow Chart of Subroutine POWERL

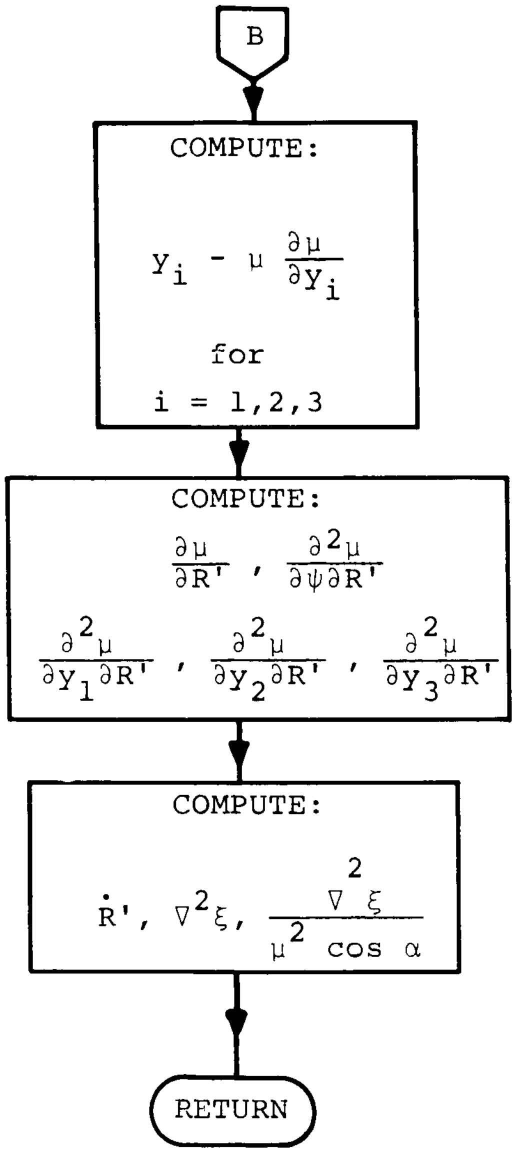


Figure 10C. - Flow Chart of Subroutine POWERL

TABLE IX

FORTRAN Name	Definition
DRPDR	$\frac{\partial r'}{\partial r}$
DRPDT	$\frac{\partial r'}{\partial \theta}$
DRPDP	$\frac{\partial r'}{\partial \phi}$
DSITP	$\cos(\phi')$
COTP	$\cos(\theta')$
COPP	$\sin(\theta)$
DRDRP	$\frac{\partial r}{\partial r'}$
DTDRP	$\frac{\partial \theta}{\partial r'}$
DPDRP	$\frac{\partial \phi}{\partial r'}$
D2MY1R	$\frac{\partial^2 M}{\partial y_1 \partial r}$
D2MY2T	$\frac{\partial^2 M}{\partial y_2 \partial \theta}$
D2MY3P	$\frac{\partial^2 M}{\partial y_3 \partial \phi}$

TABLE IX.- Continued

FORTRAN Name	Definition
D2AY1R	$\frac{\partial^2 A}{\partial y_1 \partial r}$
D2AY2T	$\frac{\partial^2 A}{\partial y_2 \partial \theta}$
D2AY3P	$\frac{\partial^2 A}{\partial y_3 \partial \phi}$
DADY1	$\frac{\partial A}{\partial y_1}$
DADY2	$\frac{\partial A}{\partial y_2}$
DADY3	$\frac{\partial A}{\partial y_3}$
DADR	$\frac{\partial A}{\partial r}$
DADT	$\frac{\partial A}{\partial \theta}$
DADP	$\frac{\partial A}{\partial \phi}$
DBDR	$\frac{\partial B}{\partial r}$
DBDT	$\frac{\partial B}{\partial \theta}$
DBDP	$\frac{\partial B}{\partial \phi}$

TABLE IX.- Continued

FORTRAN Name	Definition
DBDSI	$\frac{\partial B}{\partial \psi}$
D2MDSR	$\frac{\partial^2 M}{\partial \psi \partial R}$
D2MDST	$\frac{\partial^2 M}{\partial \psi \partial \theta}$
D2MDSP	$\frac{\partial^2 M}{\partial \psi \partial \phi}$
D2UDSR	$\frac{\partial^2 \mu}{\partial \psi \partial r}$
D2UDST	$\frac{\partial^2 \mu}{\partial \psi \partial \theta}$
D2UDSP	$\frac{\partial^2 \mu}{\partial \psi \partial \phi}$
D2UY1R	$\frac{\partial^2 \mu}{\partial Y_1 \partial r}$
D2UY2T	$\frac{\partial^2 \mu}{\partial Y_2 \partial \theta}$
D2UY3P	$\frac{\partial^2 \mu}{\partial Y_3 \partial \phi}$
YPEMDU	$Y_1 - \mu \frac{\partial \mu}{\partial Y_1}$

TABLE IX.- Concluded

FORTRAN Name	Definition
YP2MDU	$Y_2 - \mu \frac{\partial\mu}{\partial Y_2}$
YP3MDU	$Y_3 - \mu \frac{\partial\mu}{\partial Y_3}$
DMUDRP	$\frac{\partial\mu}{\partial r'}$
DUDSRP	$\frac{\partial^2\mu}{\partial\psi\partial r'}$
DUY1RP	$\frac{\partial^2\mu}{\partial Y_1 \partial r'}$
DUY2RP	$\frac{\partial^2\mu}{\partial Y_2 \partial r'}$
DUY3RP	$\frac{\partial^2\mu}{\partial Y_3 \partial r'}$
RDØTP	$\dot{r}'$
DEL2S	$\nabla^2\zeta$
YD(11)	$\dot{P}_F = \frac{\nabla^2\zeta}{\mu^2 \cos\alpha}$

Subroutine INPUT

Description.- The purpose of the INPUT routine is to bring into core the user's data and then convert it into a useable format. (See flow chart in Figure 11.) Most of the initialization

is performed here. Since all the information referring to the input section is already presented in Section II, it is sufficient to present only the flow chart and the listing of the subroutine.

Dictionary of major FORTRAN names.- Table X contains a dictionary of major FORTRAN names.

TABLE X

FORTRAN Name	Data Type	Definition
V	Numeric array	Coefficients used to calculate $N_x(r)$
W	Numeric array	Coefficients used to calculate $N_x(r)$
D	Numeric array	Dummy input array
XNAME1	Name list	Description in Section II
XNAME3	Name list	Description in Section II
XNAME5	Name list	Description in Section II
H		Scale size of electron density distribution
HPRIME		Point of maximum electron density gradient
ZX		$\frac{r}{r}(r - r)$
ENF		N_F Electron density in F region
ENXR		$N_x(r)$
ENX		N_x Electron density in exosphere
EN		Total electron density, $N_x + N_F = N$

TABLE X.- Concluded

FORTRAN Name	Data Type	Definitions
PKDELN		ΔN_O = PKFRAC * N(PKFRAC is in percent)
PLT		Array used to store plotting title information
YO	Array	Contains value of differential equations evaluated
NUAR		Number of differential equations evaluated

Subroutine Output

Description.- Final calculations are made in OUTPUT prior to printing results.

(1) DOPPLER SHIFT - DSHIFT

$$\Delta f = -(2.424067E-4).f\int_{o}^{h_p} \frac{1}{\mu}\,\frac{\partial\mu}{\partial\phi}\,dh_p$$

(2) VALIDITY CRITERION - VALCRIT

$$V_c = K\left[\left(\frac{\partial\mu}{\partial r}\right)^2 + \frac{1}{r^2}\left(\frac{\partial\mu}{\partial\theta}\right)^2 + \frac{1}{(r\cos\theta)^2}\left(\frac{\partial\mu}{\partial\phi}\right)^2\right]^{1/2}$$

where

$$K = \frac{1}{K_1 f\mu^2.10^6}$$

$$K_1 = \frac{2\pi}{c} = 2.0943933E-5$$

c = speed of light in km

f = signal frequency in megacycles/sec.

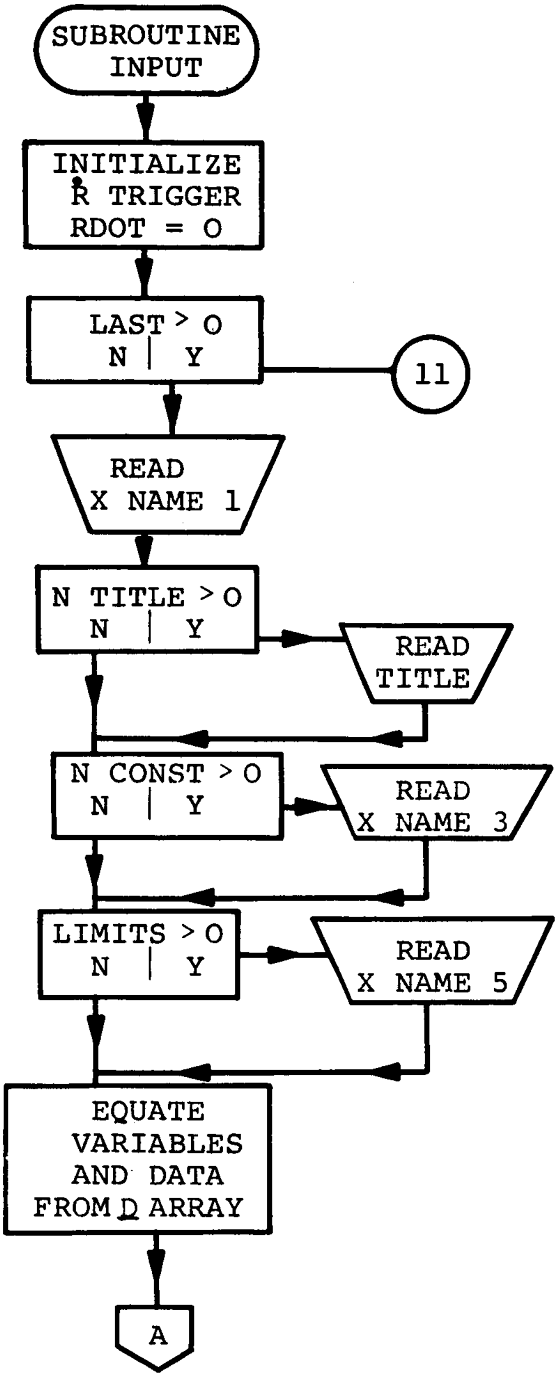


Figure 11A. - Flow Chart of Subroutine INPUT

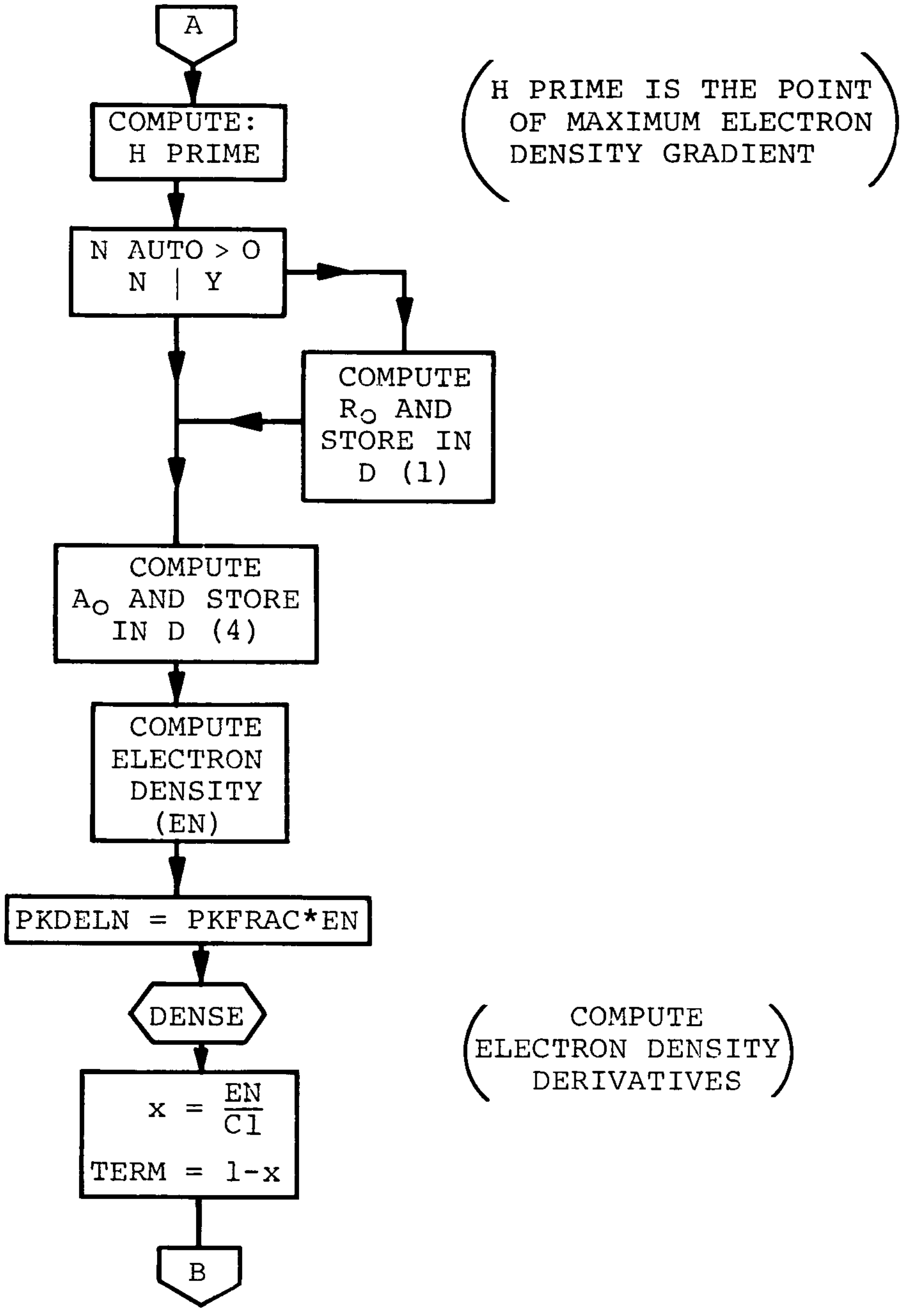


Figure 11B. - Flow Chart of Subroutine INPUT

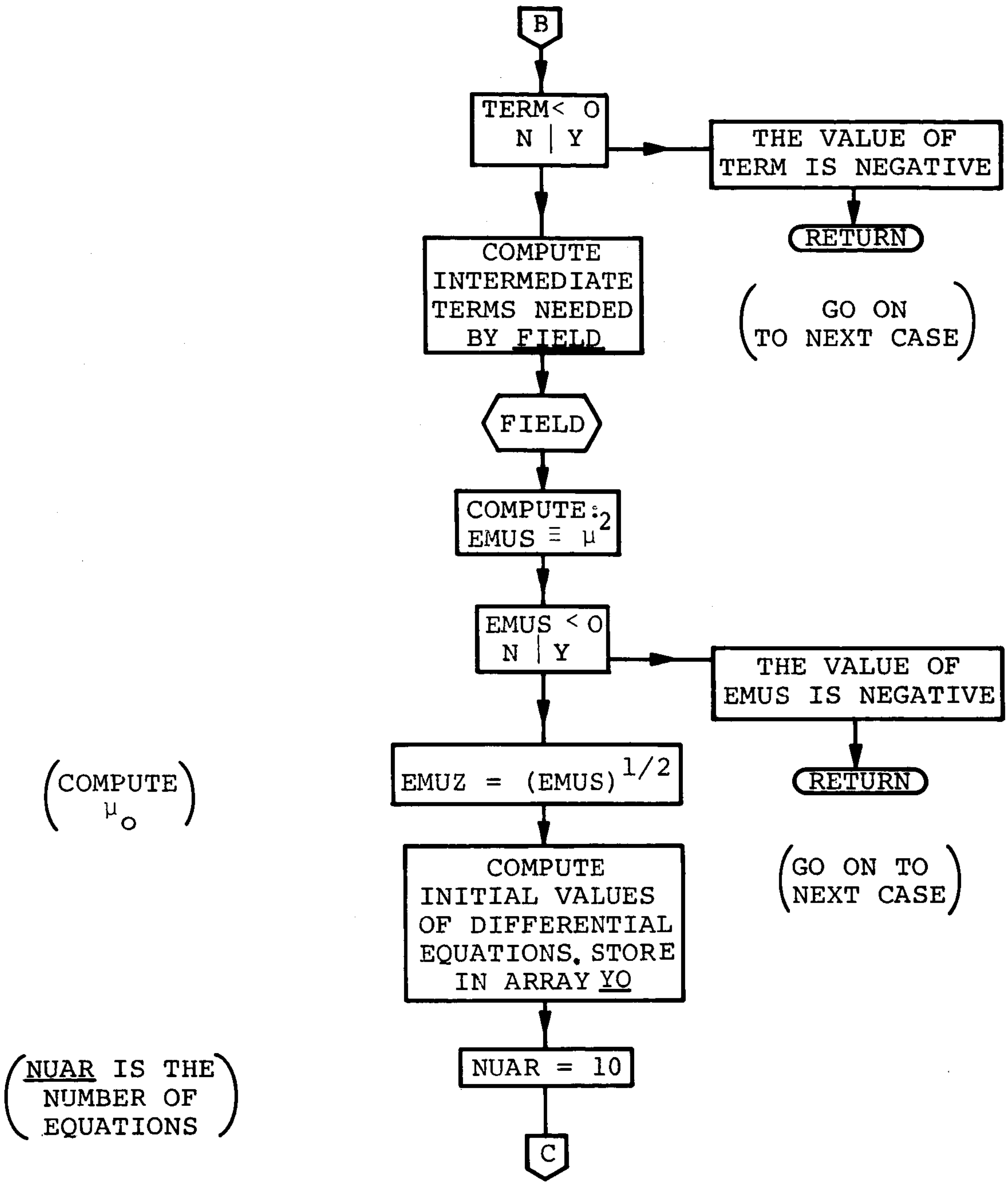


Figure 11C. - Flow Chart of Subroutine INPUT

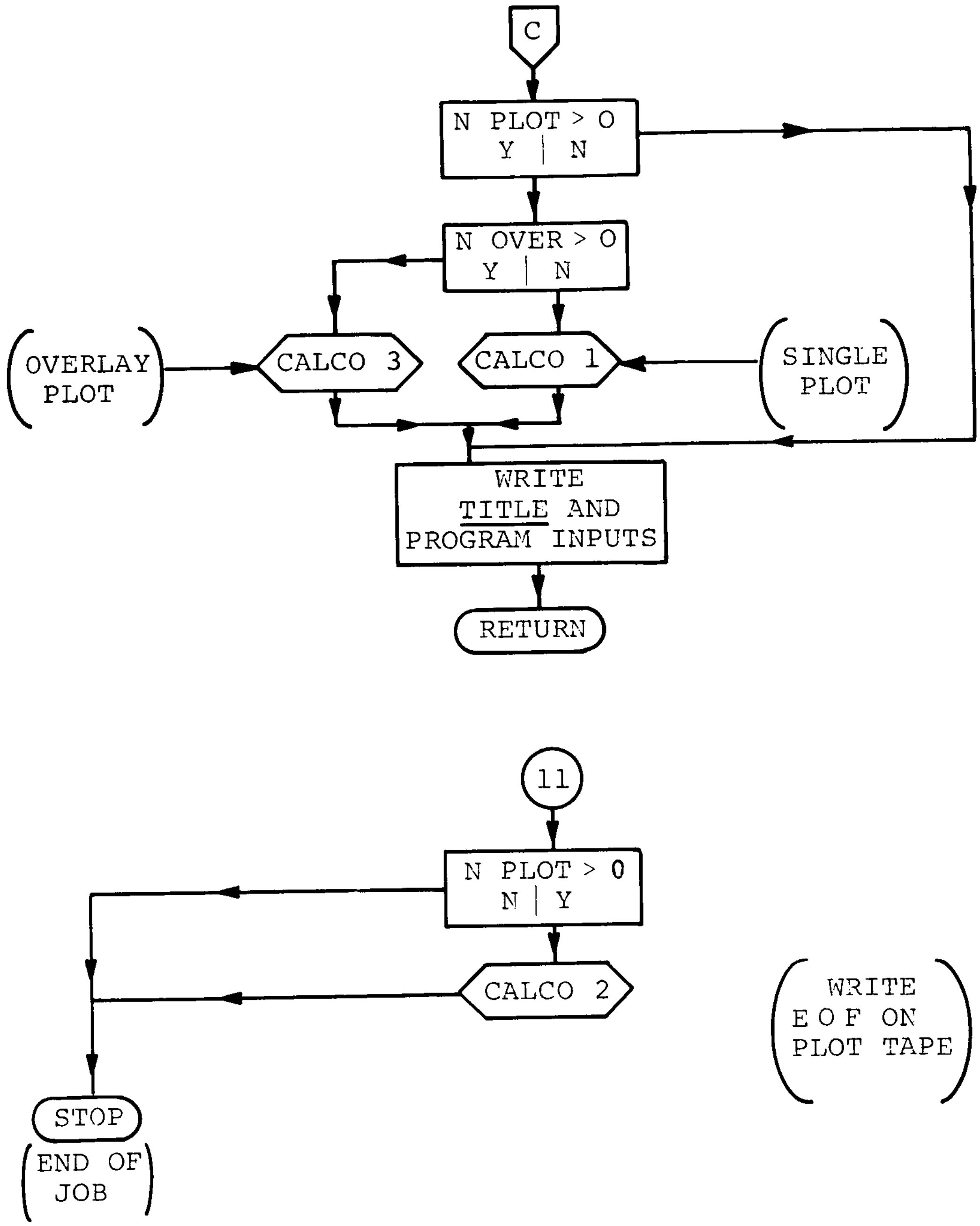


Figure 11D. - Flow Chart of Subroutine INPUT

In the flow chart convention:

$$DM\mu DR = \frac{\partial\mu}{\partial r} \qquad Y\emptyset(1) = r$$

$$DMUDT = \frac{\partial\mu}{\partial\theta} \qquad RCT = r\cos\theta$$

$$DMUDP = \frac{\partial\mu}{\partial\phi} \qquad EMUS = \mu^2$$

(3) TOTAL POWER LOSS IN DB - PL -

$$P_L = 10 \log_{10}\left(\mu \; PR\emptyset PT \;\; EXP\left[-\int_o^{h_p} \frac{\nabla^2\zeta}{\mu^2\cos\alpha}\, dh_p\right]\right)$$

where

$$YD(11) = \dot{P}_F = \frac{\nabla^2\zeta}{\mu^2\cos\alpha}$$

$$Y\emptyset(11) = \int_o^{h_p} \dot{P}_F \, dh_p$$

$$PR\emptyset PT = \frac{P_{ro}}{P_T} \times \frac{c^2}{4\pi f^2 \mu_o \times 10^{12}}$$

(4) GROUP DELAY IN MILLISECONDS - GRODEL

$$GR\emptyset DEL = \frac{1}{c} \int_o^{h_p} \left(1 + \frac{f \times 1.0E6}{\mu} \frac{\partial\mu}{\partial f}\right) dh_p$$

where f is the frequency in MHz and $dh_p = \mu \cos \alpha \; ds$.

In the flow chart convention:

$$YD(7) = \dot{G}_L = 1 + \frac{f \bullet 1.0E6}{\mu} \frac{\partial\mu}{\partial f}$$

$$YØ(7) = \int_o^{h_p} \dot{G}_L \, dh_p = G_L$$

$$GRØDEL = \frac{G_L}{c}$$

where

G_L = group path length in km

c = speed of light in km/sec

= 3 x 10^2

Also, see the flow chart, Figure 12.

Dictionary of major FORTRAN names.- Table XI contains a dictionary of major FORTRAN names, subroutine OUTPUT.

TABLE XI

FORTRAN Name	Data Type	Definition
THETA		Colatitude of wave front in degrees
PHI		Longitude of wave front in degrees
YØSQR		$[YØ(4)]^2 + [YØ(5)]^2 + [YØ(6)]^2$
DSHIFT		Doppler shift, Δf.
C2		4.24737E-6/F, used to calculate dispersion

TABLE XI.- Concluded

FORTRAN Name	Data Type	Definition
VALCRIT		Validity criterion for μ^2
PL		Total power loss in db, exclusive of absorption
GRØDEL		Group delay in milliseconds
XX	Array	Array used to store geocentric radius for plot of total ray path
YY	Array	Array used to store colatitude for plot of total ray path, theta in degrees
LL		Number of points in the XX and YY arrays 500 points maximum
JFLAG		Program indicator, used to indicate reason OUTPUT was called
JUMP		Program indicator, used to indicate that an end of case condition exists
N		Program indicator, used as a line counter

Subroutine COLL

Description.- The collision frequency model has the following functional form:

$$\nu = 10^{\nu'}$$

where ν' is computed as shown below. (Also, see flow chart, Figure 13.) The collision frequency profile as a function of

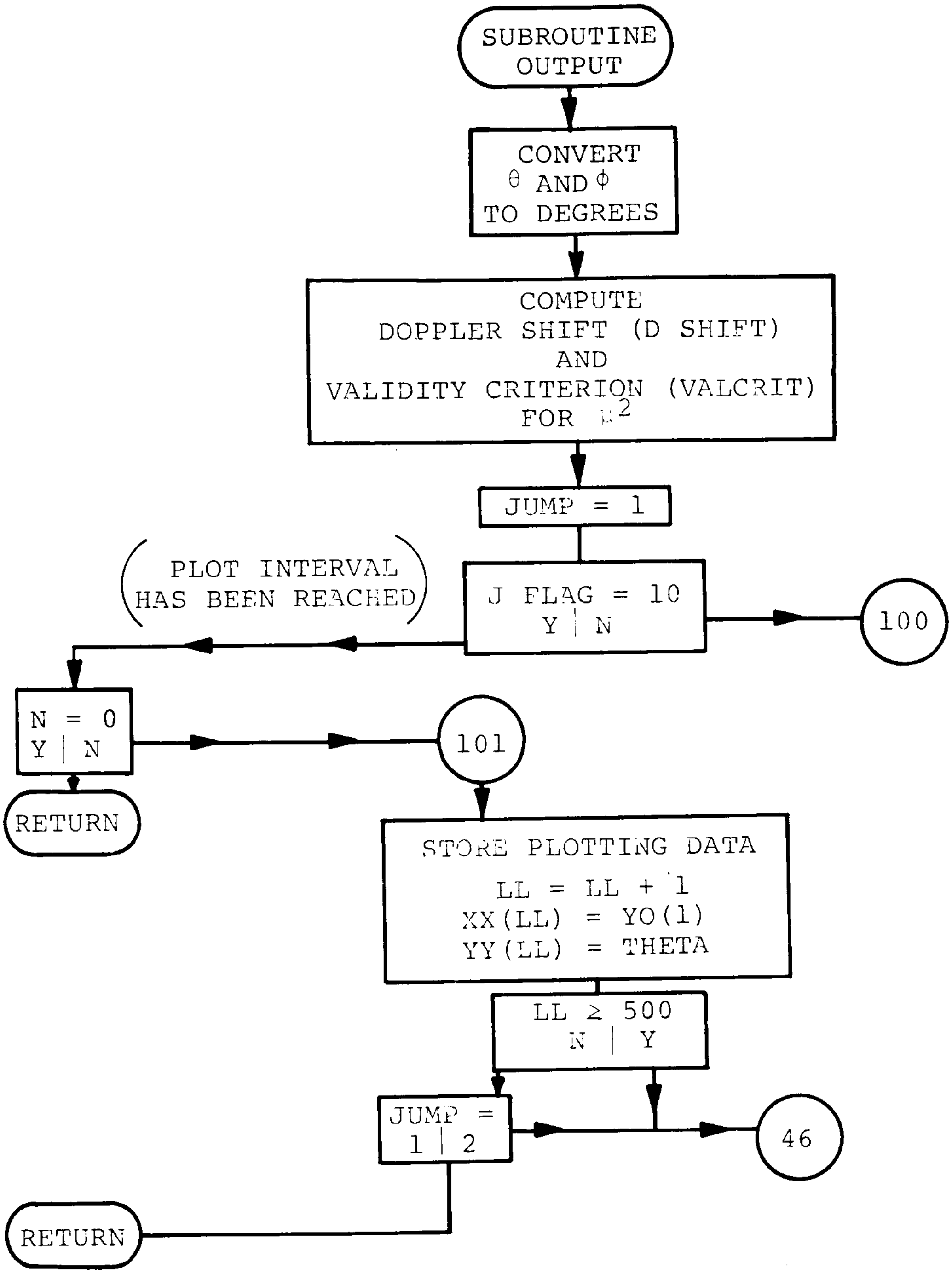


Figure 12A. - Flow Chart of Subroutine OUTPUT

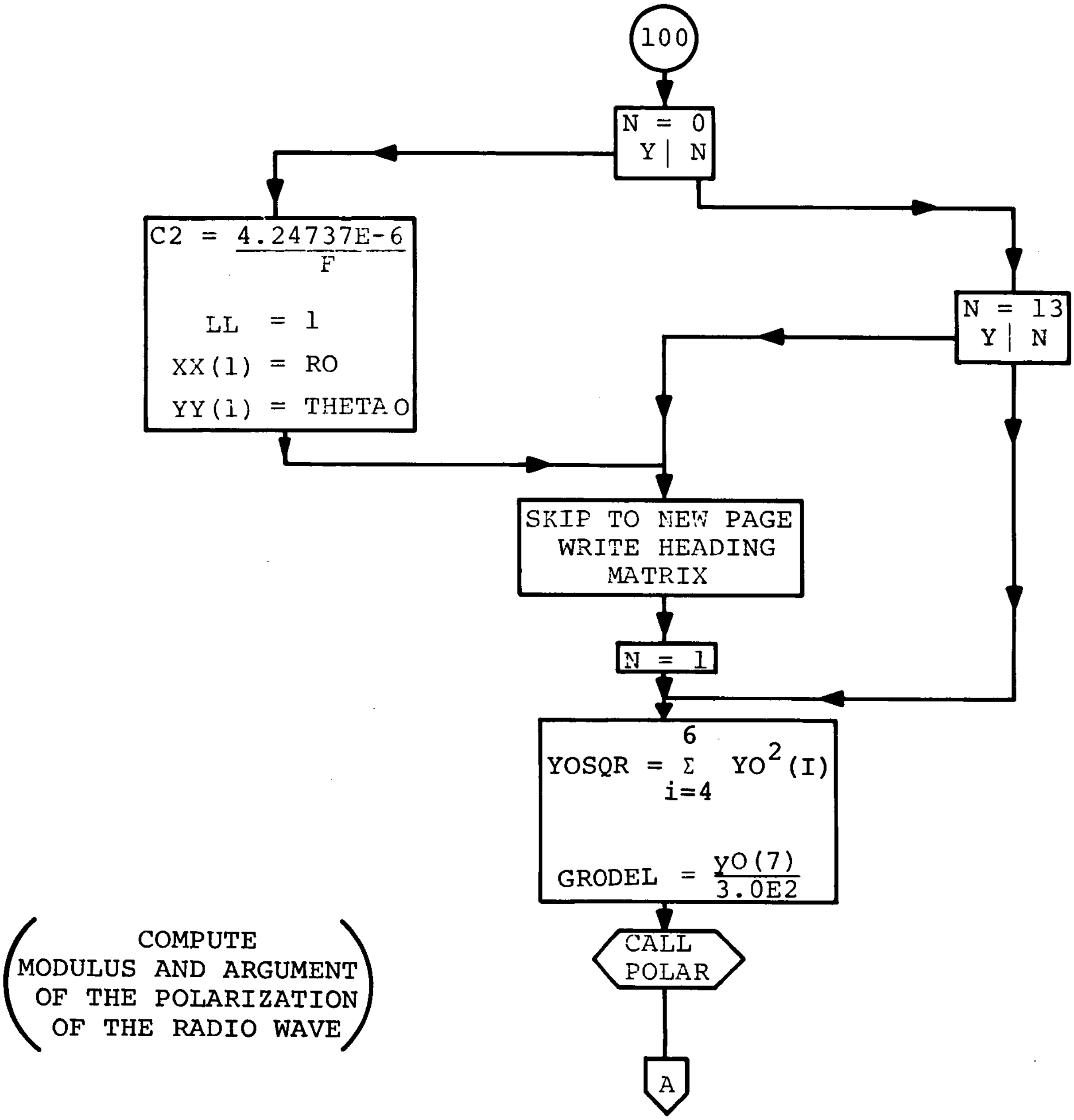


Figure 12B. - Flow Chart of Subroutine OUTPUT

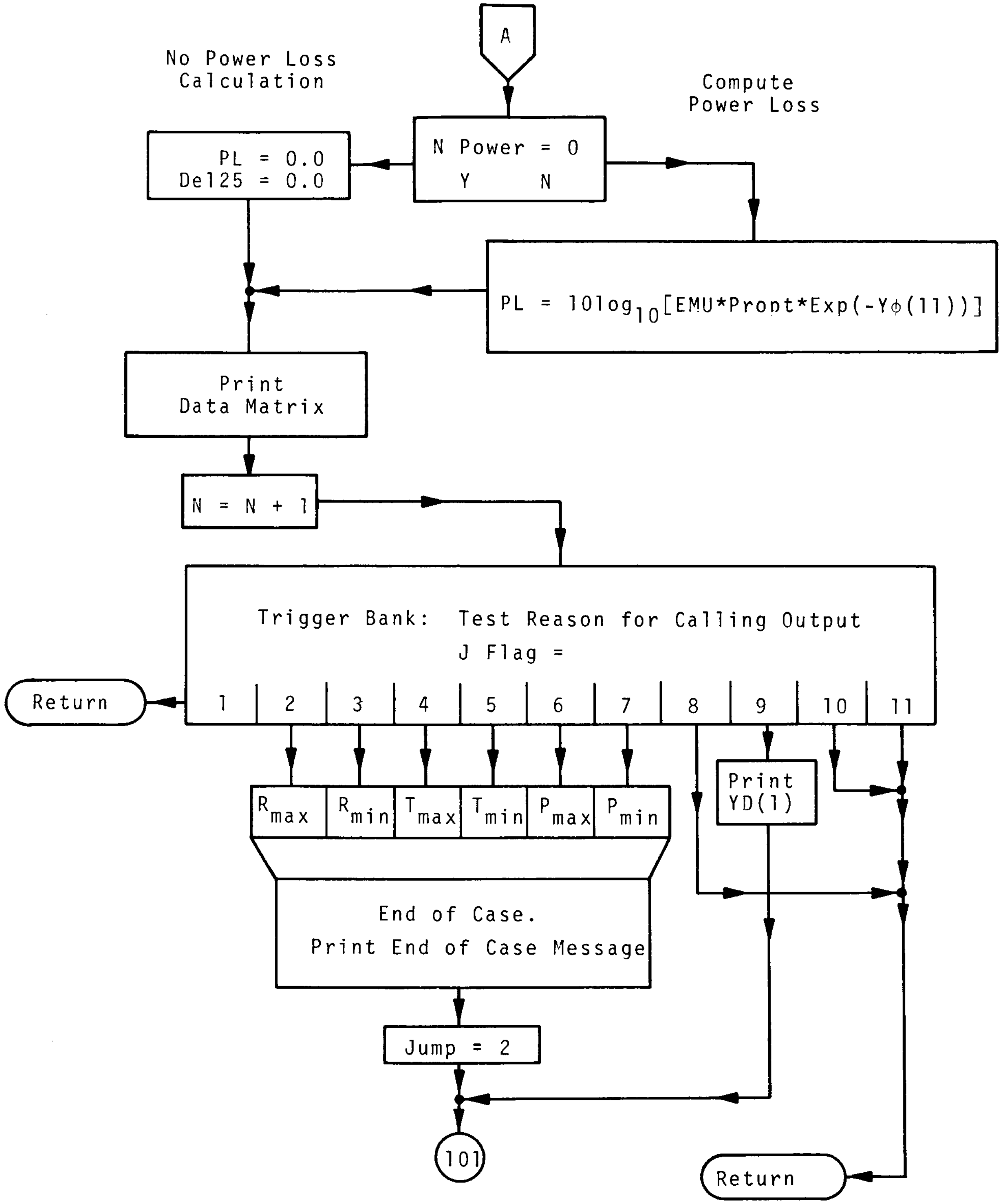
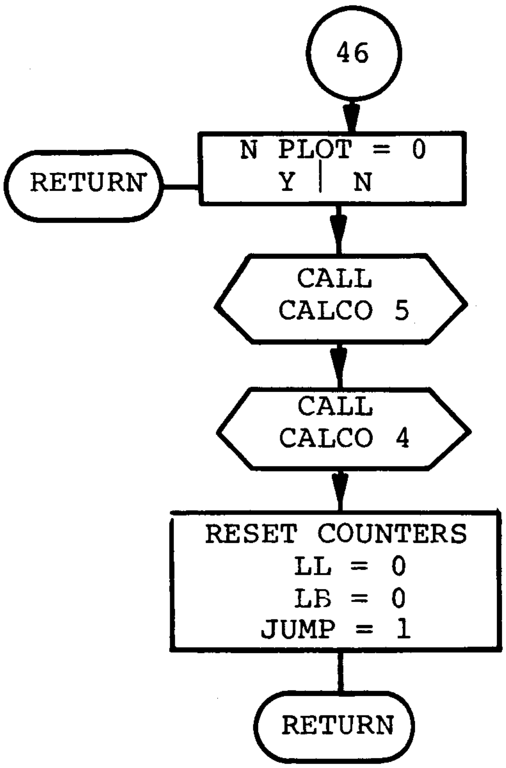


Figure 12C. - Flow Chart of Subroutine OUTPUT



TO GENERATE RECTANGULAR	PLOT	CALL	CALCO 5
TO GENERATE POLAR	PLOT	CALL	CALCO 4

BOTH PLOTS ARE DESCRIBED IN THE FOLLOWING SECTION

Figure 12D. - Flow Chart of Subroutine OUTPUT

altitude consists of three parts that are smoothly joined with the aid of a curve fitting program.

For $6378 \leqslant r \leqslant 6478$ km:

$$\nu' = 12.03527 - 0.07392\ x$$

where

$$x = (r - 6378)\ \text{km}.$$

For $6478 \leqslant r \leqslant 6853$ km:

$$\nu' = \sum_{i=1}^{6} \left[a_i + C(\theta, \phi)\, b_i \right] f_i(x)$$

where

$$f_1(x) = 1 \qquad ; x = (r - 6478)\text{km}$$

$$f_2(x) = x$$

$$f_3(x) = x^2$$

$$f_4(x) = x^3$$

$$f_5(x) = \cos(0.0157\ x)$$

$$f_6(x) = \sin(0.0157\ x)$$

$$a_1 = 5.0562 \qquad ; b_1 = 0.032512$$

$$a_2 = -3.7482 \times 10^{-2} \qquad ; b_2 = -0.8847 \times 10^{-2}$$

$$a_3 = 1.3864 \times 10^{-4} \qquad ; b_3 = 0.8541 \times 10^{-4}$$

$$a_4 = -1.4777 \times 10^{-7} \qquad ; b_4 = -1.5422 \times 10^{-7}$$

$$a_5 = -0.48192 \qquad ; b_5 = 0.01470$$

$$a_6 = -0.27021 \qquad ; b_6 = 0.65037$$

$$c(\theta, \phi) = c_1\theta^2 + c_2\theta + c_3 + (d_1\theta^2 + d_2\theta + d_3) \cos\phi$$

where

$c_1 = -0.35818$; $d_1 = -0.17828$

$c_2 = 1.1250$; $d_2 = 0.55997$

$c_3 = -0.88344$; $d_3 = 0.56028$

θ is the colatitude and ϕ is the longitude in degrees. $\phi = 0$ corresponds to local noon. For $r \geqslant 6853$ km,

$$\nu' = 2.3653 - 0.0030266\, x \bullet (0.3195 - 0.0000536\, x)\, c(\theta, \phi)$$

where

$$x = (r - 6853)$$

Also, see flow chart of subroutine COLL, Figure 13.

Subroutine FIELD

Description.- An idealized dipole model is used for the magnetic field of the Earth. The magnetic field equations which define gyrofrequency, f_H, and the angle between the magnetic field and the wave normal, ψ, are

$$f_H = c_{11} \left(\frac{a}{r}\right)^3 [\, 1 + 3\cos\theta \,]^{1/2}$$

where a = 6378 km, the radius of the Earth and r and θ are the geocentric radius and colatitude of the ray position

$$c_{11} = \frac{e}{2\pi m} B_o \bullet 10^{-6} \doteq 0.9$$

where B_o = 0.3142 Gauss is the magnetic field on the surface of the Earth at the equator and e and m are the charge and mass of an electron.

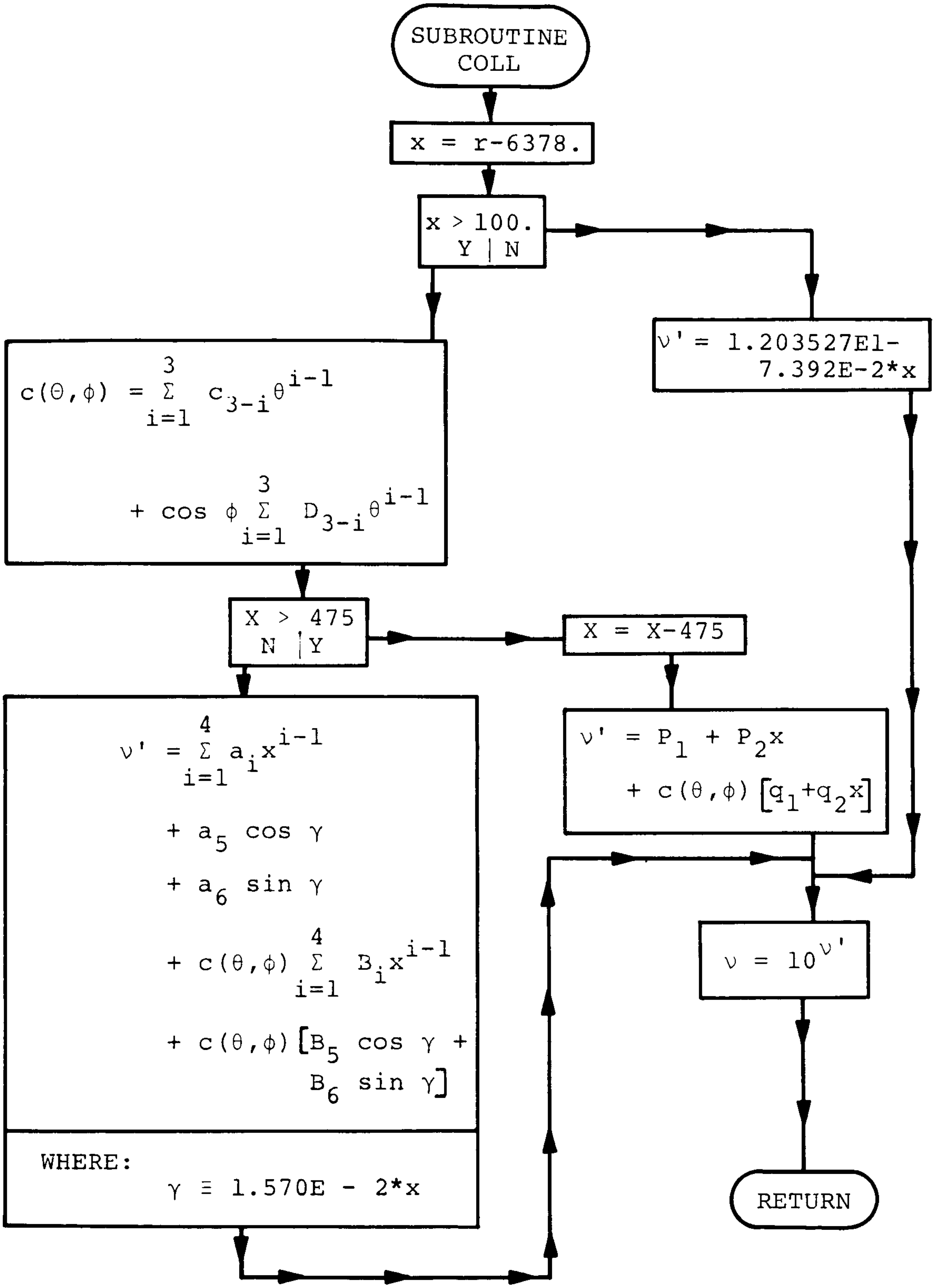


Figure 13. - Flow Chart of Subroutine COLL

$$\cos\psi = \frac{\cos\theta + Y_2\sin\theta}{\sum_{i=1}^{3} Y_L^2 \bullet [1 + 3\cos\theta]^{1/2}}$$

$$\sin\psi = \frac{2Y_2\cos\theta - Y_1\sin\theta}{|2Y_2\cos\theta - Y_1\sin\theta|} \left[1 - \cos^2\psi\right]^{1/2}$$

The derivatives of f_H and ψ are:

$$\frac{d(f_H)}{dr} = -2.7 \left(\frac{a^3}{r^4}\right) \left[1 + \cos^2\theta\right]^{1/2}$$

$$\frac{d(f_H}{d\theta} = -2.7 \left(\frac{a^3}{r^3}\right) \frac{\sin\theta\cos\theta}{\left[1 + 3\cos^2\theta\right]^{1/2}}$$

$$\frac{d(f_H)}{d\phi} = 0$$

Let

$$T_1 = \sum_{L=1}^{3} Y_L^2$$

$$T_2 = Y_1\cos\theta + \frac{1}{2} Y_2\sin\theta$$

$$T_3 = \cos^2\theta + \frac{1}{4} \sin^2\theta$$

$$T_4 = - Y_1\sin\theta + \frac{1}{2} Y_2\cos\theta$$

Then

$$\frac{d(\cos\psi)}{dr} = 0$$

$$\frac{d(\cos\psi)}{d\theta} = \frac{T_4 + \frac{3}{4}\left[\frac{T_2 \sin\theta\cos\theta}{T_3}\right]}{(T_1)^{1/2} \bullet (T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{d\,\phi} = 0$$

$$\frac{d(\cos\psi)}{dY_1} = \frac{\cos\theta - \left[\frac{Y_1 \bullet T_2}{T_1}\right]}{(T_1)^{1/2}(T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{dY_2} = \frac{\frac{1}{2}\sin\theta - \left[\frac{Y_2 \bullet T_2}{T_1}\right]}{(T_1)^{1/2}(T_3)^{1/2}}$$

$$\frac{d(\cos\psi)}{dY_3} = \frac{-Y_3\cos\psi}{T_1}$$

$$\frac{d^2(\cos\psi)}{dY_2\,d\theta} = -\frac{d(\cos\psi)}{d\theta}\frac{Y_2}{T_1} + \frac{4\cos\theta}{(T_1)^{1/2}(T_3)^{1/2}\left[1 + 3\cos^2\theta\right]^2}$$

$$\frac{d^2(\sin\psi)}{dY_2\,d\theta} = -\frac{1}{\sin\psi}\left[\cos\psi\frac{d^2(\cos\psi)}{dY_2\,d\theta} + \frac{d(\cos\psi)}{d\theta}\frac{d(\cos\psi)}{dY_2} \bullet \frac{1}{\sin^2\psi}\right]$$

Also, see flow chart, Figure 14.

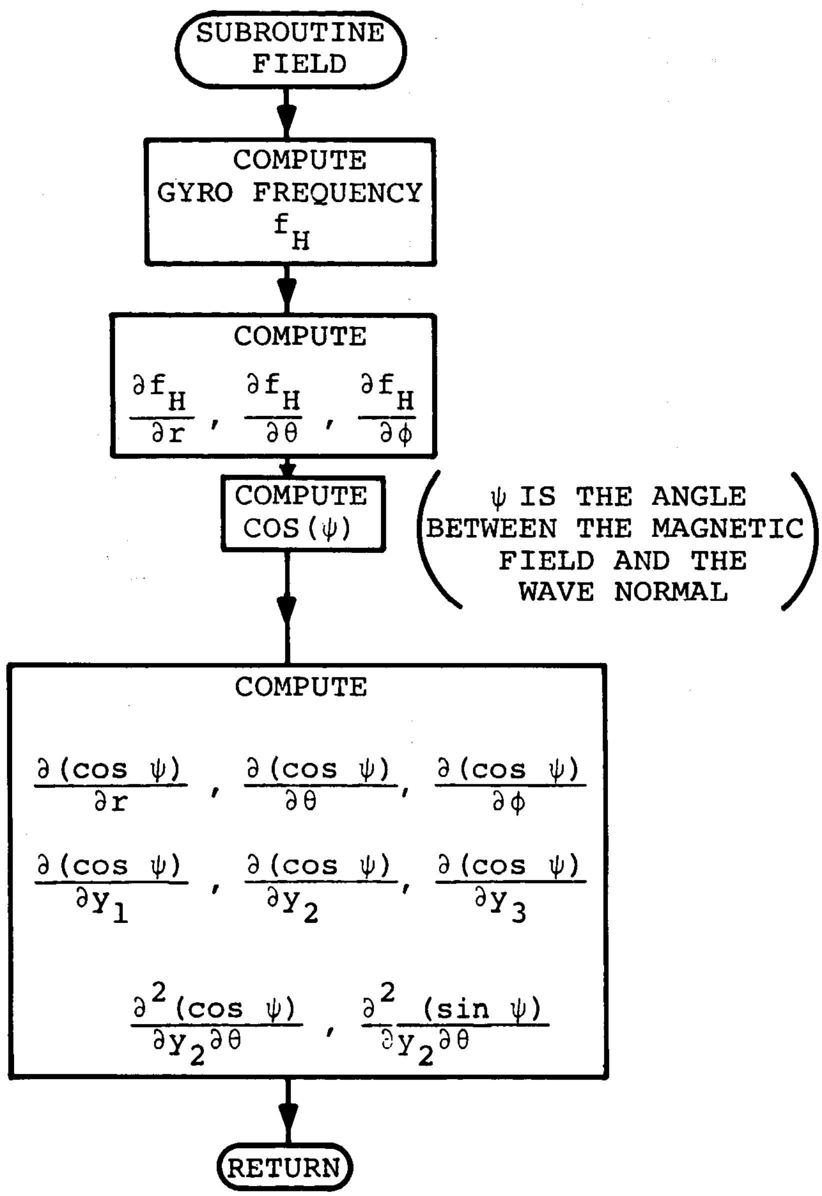


Figure 14. - Flow Chart of Subroutine FIELD

Dictionary of major FORTRAN names.- Table XII contains a dictionary of major FORTRAN names, subroutine FIELD.

TABLE XII

FORTRAN Name	Definition
FH	f_H, gyrofrequency in MHz
DFHDR	$\frac{d(f_H)}{dr}$
DFHDQ	$\frac{d(f_H)}{d\theta}$
DFHDP	$\frac{d(f_H)}{d\phi}$
COSPSI	$\cos(\psi)$
SP2	$1 - \cos^2(\psi)$
DCPDR	$\frac{d(\cos\psi)}{dr} = 0$
DCPDT	$\frac{d(\cos\psi)}{d\theta}$
DCPDP	$\frac{d(\cos\psi)}{d\phi} = 0$
DCPDY1	$\frac{d(\cos\psi)}{dY_1}$

TABLE XII.- Concluded

FORTRAN Name	Definition
DCPDY2	$\frac{d(\cos\psi)}{dY_2}$
DCPDY3	$\frac{d(\cos\psi)}{dY_3}$
D2CY2T	$\frac{d(\cos\psi)}{d(Y_2)d(\theta)}$
D2SY2T	$\frac{d(\sin\psi)}{dY_2\, d\theta}$

Subroutine DENSE

Description.- The electron density is given by

$$N(r,\theta,\phi) = N_1(r,\theta) \bullet N_2(r,\theta,\phi)$$

where r is the geocentric radius, θ is the colatitude, and ϕ is the magnetic longitude.

$N_1(r,\theta)$ represents the background density in the magnetic meridional plane and $N_2(r,\theta,\phi)$ represents the ionization of the field-aligned irregularities in both the meridional and azimuthal planes.

The background ionization is assumed to have the form:

$$N_1(r,\theta) = N_F + N_x$$

where

N_F = electron density in the F-region

N_x = electron density in the exosphere

$N_F = N_{max}*EXP[1/2 \left\{ 1-W-e^{-W} \right\}]$

N_{max} is assumed to be 2.7E5

and

$$W = \frac{h - h_{max}}{H_F}$$

h_{max} = altitude of the peak electron density N_{max}

H_F = the scale height

h_{max} = 350 km

H_F = 50 km

The electron density in the exosphere is given by:

$$N_x = N_r \times \left[1.659E3 \bullet \theta + 1.662E4\right]$$

where θ is the colatitude in radians.

$$N_r = \left[\sum_{i=1}^{3} \beta_i \exp\left(-\frac{Z_x}{H_i}\right)\right]^{1/2}$$

where Z_x is the geopotential altitude given by:

$$Z_x = \frac{r_o}{r}(r - r_o)$$

where r_o is the reference radial distance and is equal to 6878 in the model.

The symbol i refers to each ion present in the exosphere. H_i and β_i refer to the scale height and the fractional density of the i-th ion at the reference level r_o.

A three-ion gas model consisting of oxygen (O^+), helium (He^+), and hydrogen (H^+) ions is assumed. The various parameters in the density equation have the following values:

ion_i	β_i	H_i
O^+	.9788	66.546
H^+	.0016	1056.3
He^+	.0196	265.98

The technique suggested by Swayze is used to join the exospheric profile smoothly with that of the F-layer between 350 and 1000 km. The expression N_x is modulated by a factor

$$\mathrm{EXP}\left[-\left(\frac{h-1000}{500}\right)^{2}\right]$$

where h is the altitude in km.

The model for the field aligned ionization irregularities is given by:

$$N_2(r,\theta) = 1 + \frac{\Delta N_o}{\left(N \bullet \frac{t}{t_o}\right)} \bullet \mathrm{EXP}\left[-\left(\frac{\Delta z}{H_o\left(\frac{t}{t_o}\right)}\right)^{2}\right]$$

N_O is the peak ionization enhancement and H_O is the scale size of the irregularity at the base of the field line

$$\frac{t}{t_o} = \frac{\text{meridional width at } (r,\theta)}{\text{meridional width at } (r_o,\theta_o)}$$

$$= \frac{\sin^3\theta(4-3\sin^2\theta_o)^{1/2}}{\sin^3\theta_o(4-3\sin^2\theta)^{1/2}}$$

$$N_F = N_{max} \bullet \exp\left[\frac{1}{2}\left(1-W-e^{-W}\right)\right]$$

$$\frac{dN_F}{dr} = N_F \bullet \left(-\frac{1}{2H_F}\right)\left(1-e^{-W}\right)$$

Since $H_F = 50$ km

$$\frac{dN_F}{dr} = N_F \times 10^{-2}(e^{-W}-1)$$

$$\frac{dN_F}{d\theta} = 0$$

$$N_x = N_r[K_1\theta + K_2]$$

where K_1 and K_2 are constants and θ is the colatitude.

$$N_r = \left[\sum_{i=1}^{3} \beta_i \exp\left(- \frac{Z_x}{H_i} \right) \right]^{1/2}$$

where

$$Z_x = \frac{r_o}{r} (r - r_o)$$

$$\frac{dN_x}{dr} = - \frac{(K_1\theta + K_2)}{2N_r} \left[\sum_{i=1}^{3} \frac{\beta_i}{H_i} \exp\left(- \frac{Z_x}{H_i} \right) \right] \frac{dZ_x}{dr} .$$

But,

$$\frac{dZ_x}{dr} = \frac{r_o^2}{r^2}$$

$$\frac{dN_x}{dr} = - \frac{(K_1\theta + K_2)}{2N_r} \cdot \frac{r_o^2}{r^2} \left[\sum_{i=1}^{3} \frac{\beta_i}{H_i} \exp\left(- \frac{Z_x}{H_i} \right) \right]$$

$$\frac{dN_x}{d\theta} = K_1 N_r .$$

If N_x is modulated by the factor

$$F_r = \exp \left[- \left(\frac{r-7378}{500} \right)^2 \right]$$

for $r < 7378$ km.

$$\frac{dN_x'}{dr} = \frac{d(N_x \cdot F_r)}{dr} = \frac{dN_x}{dr} \bullet F_r + N_x \frac{dF_r}{dr} .$$

$$\frac{dF_r}{dr} = F_r \bullet \left(\frac{7378-r}{125000} \right)$$

Similarly,

$$\frac{dN'_x}{d\theta} = \frac{d(N_x \cdot F_r)}{d\theta} = F_r \bullet \frac{dN_x}{d\theta}$$

$$= K_1 N_r \bullet F_r$$

DIS refers to the normal distance of the ray-position (r, θ, ϕ) from a field-line of colatitude λ.

$$\text{DIS} = r \bullet \frac{\left(1 - \frac{a}{r} \frac{\sin^2\theta}{\sin^2\lambda}\right)}{\left(1 + \frac{4}{\tan^2\theta_1}\right)}$$

where

$$\theta_1 = \theta + \left\{1 - \frac{a}{r} \bullet \frac{\sin^2\theta}{\sin^2\lambda} \quad \frac{\frac{2}{\tan\theta}}{\left(1 + \frac{4}{\tan^2\theta}\right)}\right\}$$

SOA refers to the geometrical path length in Earth radii of any arbitrary ray-position (r, θ) from its initial position (r_o, θ_o) along the same magnetic field line of the colatitude λ.

$$\text{SOA} = \frac{\sqrt{3}}{\sin^2\lambda} \left[\left(\frac{4}{3} - \sin^2\theta\right)^{1/2} \cos\theta - \left(\frac{4}{3} - \sin^2\theta_o\right)^{1/2} \cos\theta_o + \frac{1}{3} \log \left| \frac{\left(\frac{4}{3} - \sin^2\theta\right)^{1/2} + \cos\theta}{\left(\frac{4}{3} - \sin^2\theta_o\right)^{1/2} + \cos\theta_o} \right| \right]$$

Also, see flow chart, Figure 15.

Dictionary of major FORTRAN names.- Table XIII contains a dictionary of major FORTRAN names, subroutine DENSE.

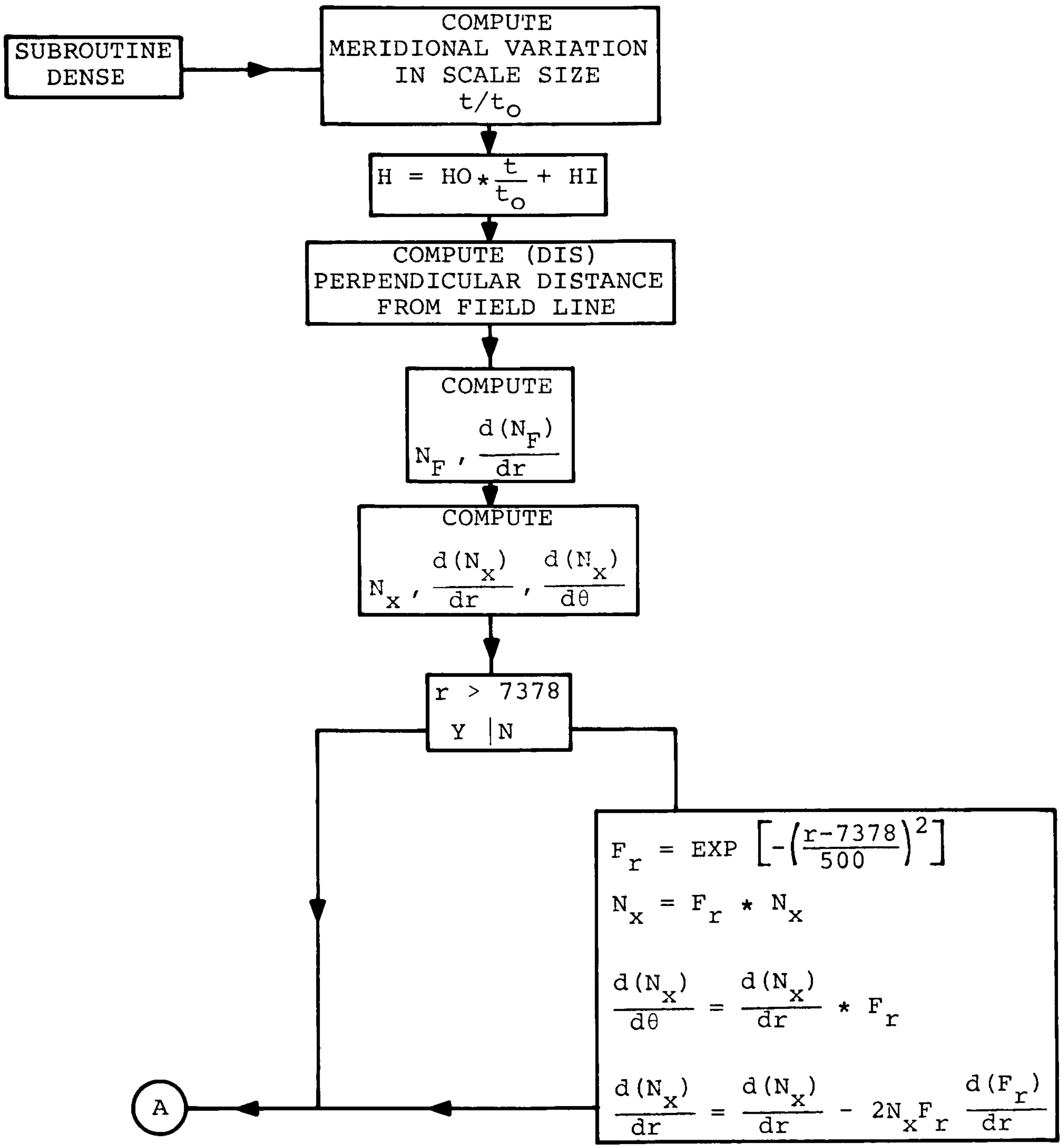


Figure 15A. - Flow Chart of Subroutine DENSE

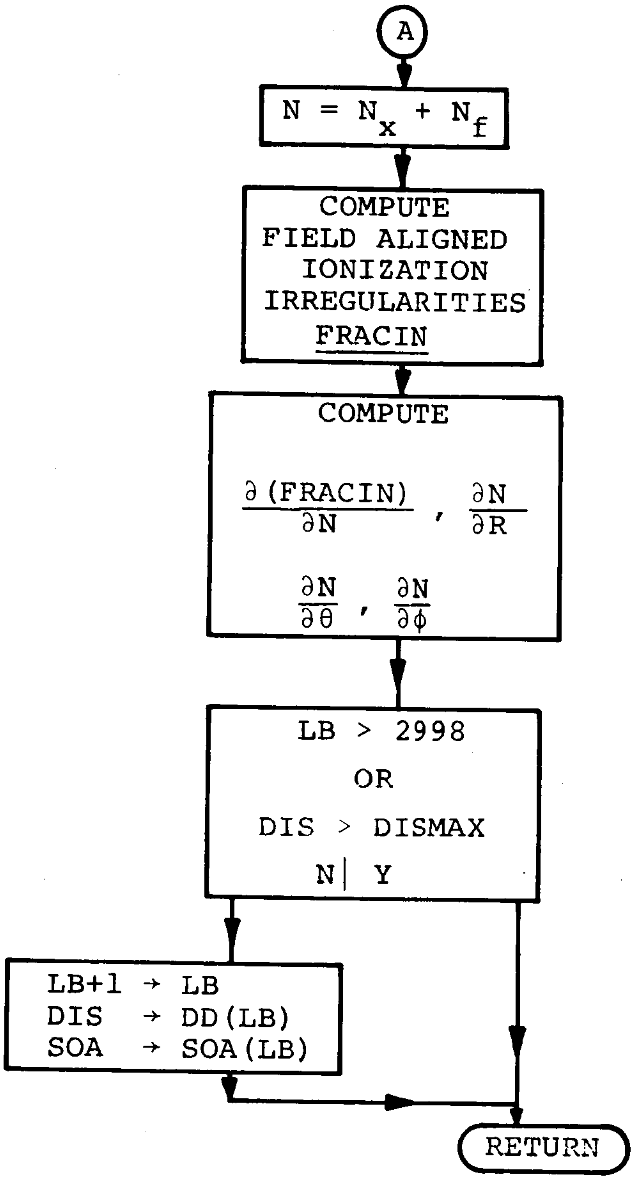


Figure 15B. -- Flow Chart of Subroutine DENSE

TABLE XIII

FORTRAN Name	Data Type	Definition
ENF		N_F - Electron density in the F-region
ENX		N_X - Electron density in the exosphere
ZX		$\frac{r_o}{r}(r - r_o)$ - geopotential altitude
ENXR		$\Sigma\beta_i \bullet \mathrm{EXP}\left(-\frac{Z_x}{H_i}\right)$
DZXDR		$\frac{d(Z_x)}{dr}$
DENFDR		$\frac{d(N_F)}{dr}$
DENXDR		$\frac{d(N_x)}{dr}$
DENXDT		$\frac{d(N_x)}{d\theta}$
R	r	Geocenter radius of wave front, in km
TH	θ	Colatitude of wave front, in radians
AMBDA	λ	Colatitude of point where the field line intersects the Earth's surface, in radians

TABLE XIII.- Concluded

FORTRAN Name	Data Type	Definition
ZM5	$\frac{t}{t_o}$	$\frac{\text{meridional width at } (r,\theta)}{\text{meridional width at } (r_o,\theta_o)}$ modulation factor if variable width duct is considered
H	$\frac{t}{t_o} H_o$	Scale size of the field line at (r,θ,ϕ)
DIS		Distance perpendicular from (r,θ,ϕ) to field line
DD		Plotting array used to store distance from field line, DIS
SØA		Plotting array used to store distance along field line

Subroutine CALCØ5

Description.- This subroutine does the plotting for the ray tracing program. All plotting operations are performed by this routine.

Two types of plot are generated by this program. The first is a rectangular plot of distance from the field line vs. distance along the field line from near end. The polar plot shows the total ray path with respect to the Earth. All distances are in kilometers.

Multiple entry points allow the user to obtain either one or both of the plots. The user also has the option of overlaying successive plots.

This subroutine has entry points CALCO4 and CALCO5 in subroutine OUTPUT. CALCO1, CALCO2 and CALCO3 are called by INPUT.

This subroutine in turn calls subroutine AXIS, SYMBOL, NUMBER, LINE and PLOT. These are standard calcomp plotting subroutines and are described in Bulletin #170-C, Programming for Calcomp Digital Incremental Plotters, by California Computer Products, Inc.

The subroutine PRAM calculates the adjusted minimum and delta required by the line and axis subroutines.

Restrictions of CALCO4

Titling - Because only one set of axes is drawn, when using the overlay option, titling information for the overlayed plots is not printed. The user should know beforehand the content of the plot.

Also, see flow chart, Figure 16.

Dictionary of major FORTRAN Names.- Table XIV contains a table of major FORTRAN names, subroutine CALCO5.

TABLE XIV

FORTRAN Name	Data Type	Definition
PLDAT	Numeric array	Working storage for plot subroutine
X	Numeric array	X coordinates to be plotted
Y	Numeric array	Y coordinates to be plotted
LL	Scalar	Number of points in X and Y arrays
DATE	Alphanumeric array	20 characters reserved for data
PLT	Numeric array	Numeric values of labling information
XMAXO XMINO	Scalar	Maximum and minimum values of the X-axis for the rectangular plot of the distance from the field line vs. the distance along the field line
YMAXO YMINO	Scalar	Maximum and minimum values of the Y-axis for the rectangular plot of the distance from the field line vs. the distance along the field line
XMAX1 XMIN1	Scalar	Maximum and minimum values of the X-axis for the polar plot of ray path
YMAX1 YMAX1	Scalar	Maximum and minimum values of the Y-axis for the polar plot of ray path

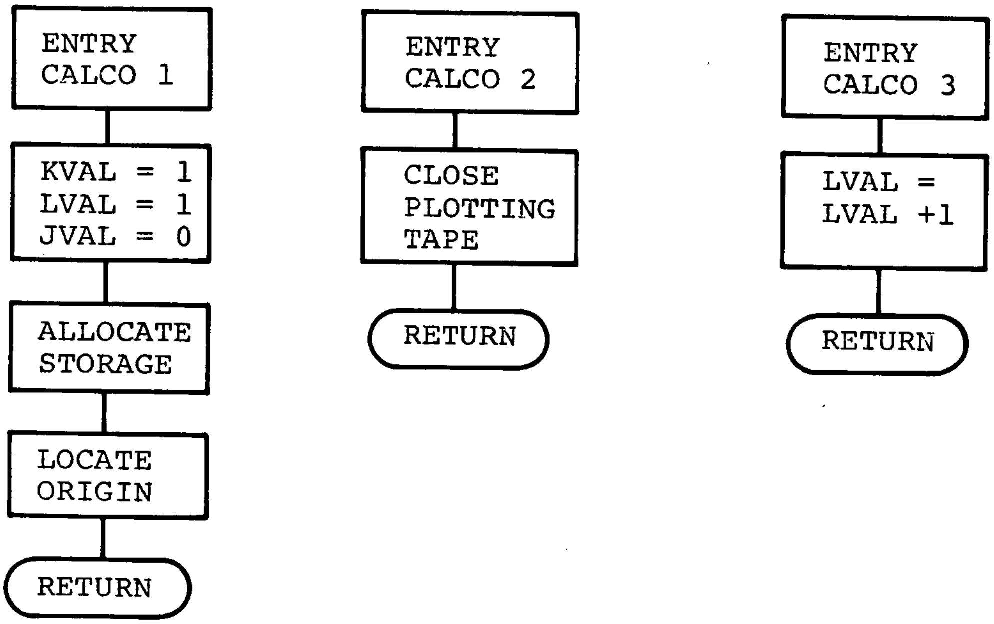


Figure 16A. - Flow Chart of Subroutine CALCO

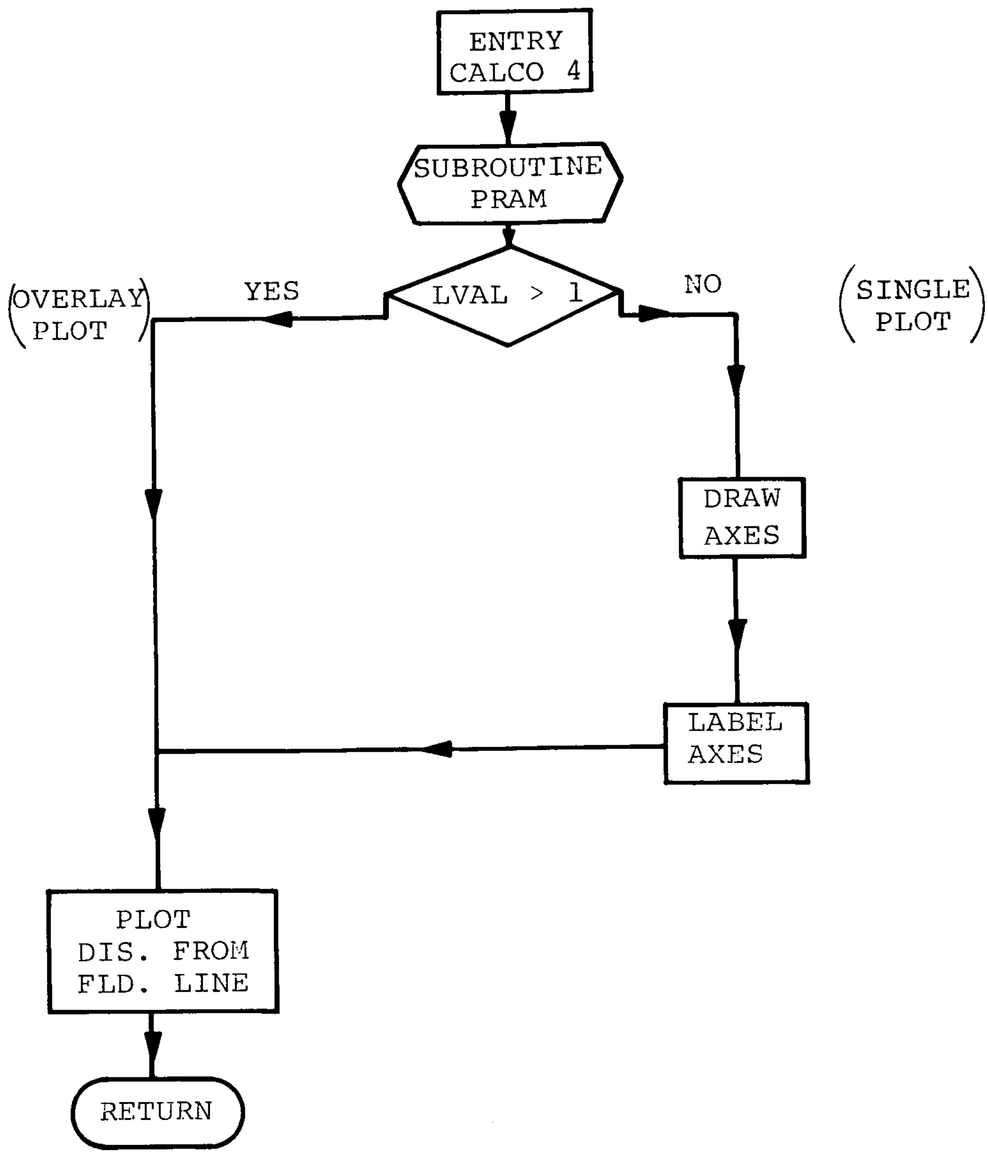


Figure 16B. - Flow Chart of Subroutine CALCO

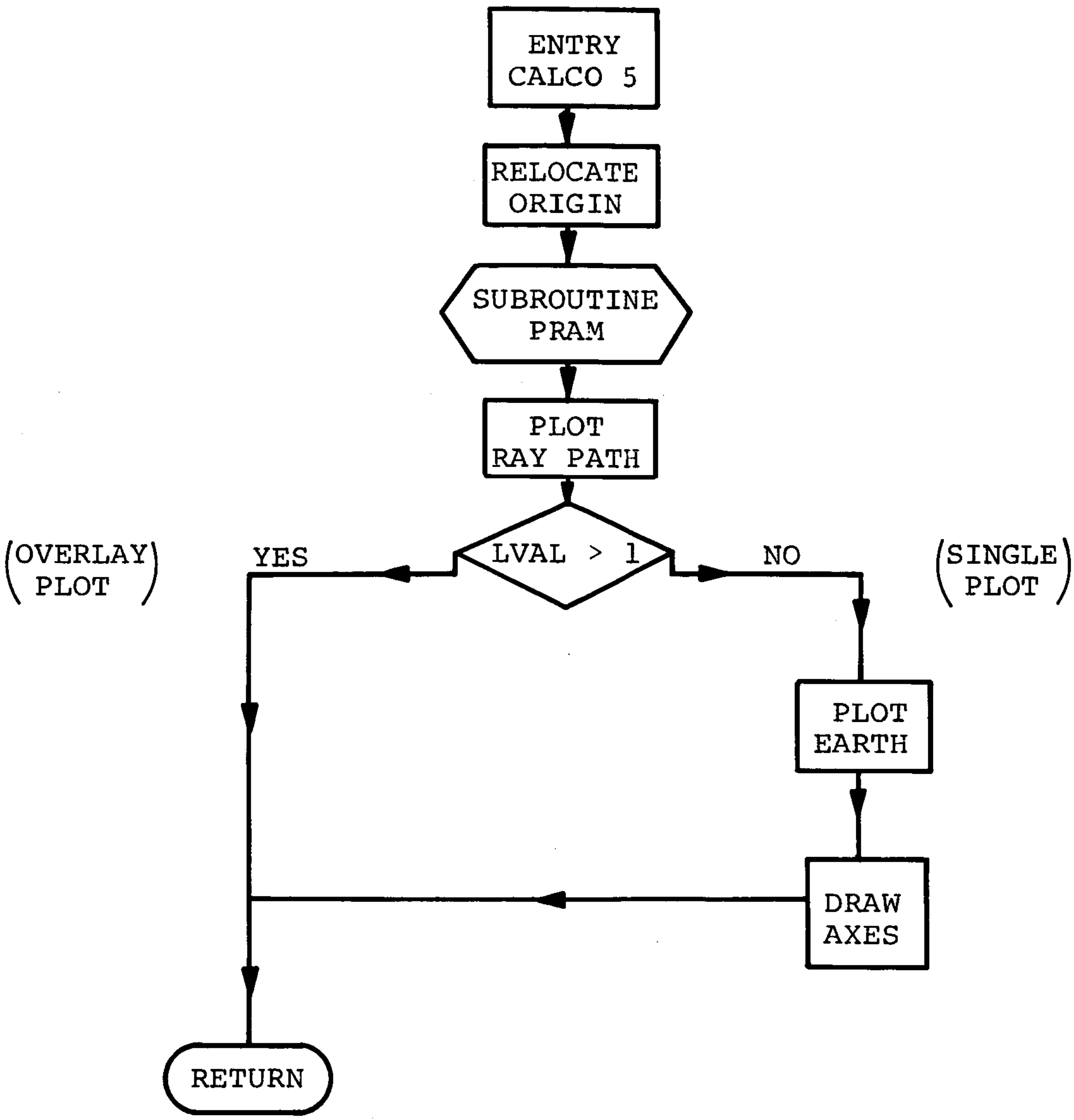


Figure 16C. - Flow Chart of Subroutine CALCO

Subroutine FORCE

Description.- Subroutine FORCE solves the equation.

$$Y_1^2 + Y_2^2 + Y_3^2 = \mu^2 .$$

In theory this relationship holds all along the ray path but in fact it does not. We make it hold by scaling Y_1, Y_2 and Y_3 down proportionately. This process is called "Normalization" of the Y vector. FORCE is called by MAIN only.

Also see flow chart, Figure 17.

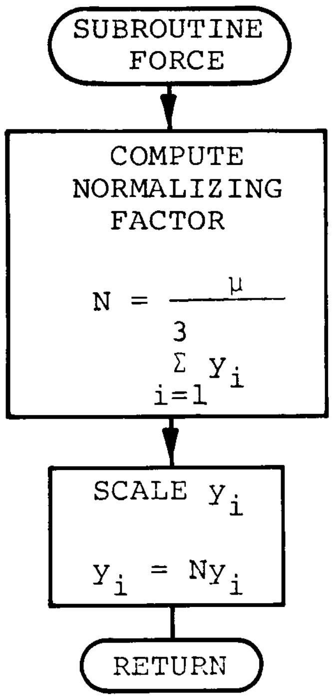


Figure 17. - Flow Chart of Subroutine FORCE

Subroutine POLAR

Description.- The expression $R = E_{\bar{x}}/E_{\bar{y}}$, a complex number, is the polarization term. $E_{\bar{x}}$ and $E_{\bar{y}}$ are the components of the electric vector of the wave along axes $(\bar{x},\bar{y})$ in the wave front, $\bar{y}$ being in and $\bar{x}$ perpendicular to the plane containing the magnetic field of the Earth.

$$|R| = \text{modulus of } R = \frac{1}{Y_L}\left[\frac{\frac{1}{4}\,Y_T^4 + A \pm Y_T^2\,A^{1/2}\cos\frac{\theta}{2}}{d}\right]^{1/2}$$

$$\Phi = \text{argument of } R = \tan^{-1}\frac{-\frac{1}{2}(1-X)Y_T^2 \pm A^{1/2}\left(\cos\frac{\theta}{2}(1-X) - Z\sin\frac{\theta}{2}\right)}{\frac{1}{2}ZY_T^2 \pm A^{1/2}\left(\sin\frac{\theta}{2}(1-X) + Z\cos\frac{\theta}{2}\right)}$$

$$d = (1-X)^2 + Z^2$$

$$A = \left\{\left[\frac{1}{4}Y_T^4 + Y_L^2\,d\right]^2 + \left[2ZY_L^2(1-X)\right]^2\right\}^{1/2}$$

where

$$\theta = \tan^{-1}\left\{\frac{-2(1-X)\,Z\,Y_L^2}{\frac{1}{4}Y_T^4 + Y_L^2\,d}\right\}$$

Also, see flow chart, Figure 18.

Mathematical Subroutines

CST1 and TOR.- CST1 evaluates the sine and cosine integrals $S_i(x)$ and $C_i(x)$. It is called only in MAIN and in turn calls TOR. TOR evaluates n! and is called only by CST1.

Minv.- MINV solves three sets of three simultaneous equations using a Gaussian method with pivot selection. It is called by POWERL and calls no other subroutine.

SMARK and MARK.- Subroutines SMARK and MARK constitute the integration package. MARK is a MAP language subroutine originally written by the Jet Propulsion Laboratory. The purpose of SMARK is to allow an interface with the main program written in FORTRAN IV.

Listings of the five mathematical subroutines are appended in Appendix B. A complete description of the integration package is found in Appendix A.

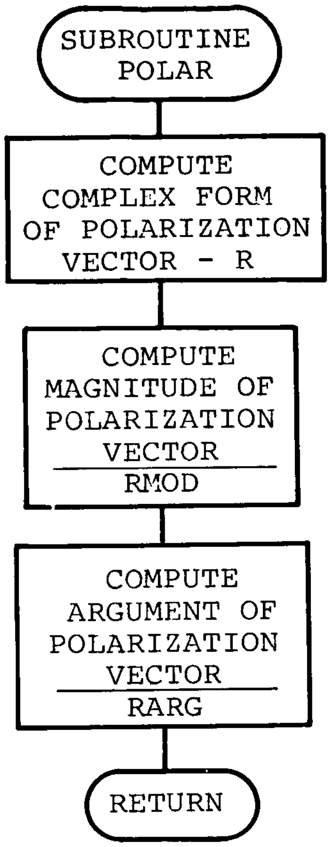


Figure 18. - Flow Chart of Subroutine POLAR

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APPENDIX A

DESCRIPTION OF THE INTEGRATION PACKAGE

Introduction

The integration package is composed of two subroutines, SMARK and MARK, both written in the MAP assembly language. Subroutine SMARK serves as a connecting link between the FORTRAN IV monitor and subroutine MARK. Subroutine MARK as originally written was designed to operate in a non-FORTRAN environment. The integration of the differential equations is performed by MARK.

Subroutine SMARK

This subroutine is buffer between MARK, a differential equation solving routine written in MAP language, and a main program written in FORTRAN. SMARK allows a program written in FORTRAN IV to use most of the features of MARK.

Usage of SMARK.- A knowledge of MARK is assumed.

Calling sequences:

CALL SMARK , KIND, N.HBANK, NRTN, NTRG

EUBAR, ELBAR, HMAXT, HMINT, YCLOW

LV1, TV1,

LV2, TV2,

LV3, TV3, etc.,

. . . . . up to 10 triggers

where

KIND = type of integration

0 = fixed AM integration

2 = RK integration

4 = Variable Adams-Moulton integration

N = actual number of differential equations

HBANK = location of a bank of storage used by MARK equivalent to HBANK-3

NRTN = return indicator from SMARK

1 = EOS

2 = DER1

3 = DER2

4 = trigger return

5 = error return

NTRG = return indicator from SMARK which designates which trigger has been activated. 1 for first trigger, 2 for second, etc.

EUBAR, ELBAR, HMAXT, HMINT, YCLOW same as in MARK

LV1 = location of variable being tested

TV1 = location of desired value of the variable tested

CALL TRA14 returns control to SMARK and causes a TRA 1,4 return to MARK.

CALL TRA24 returns control to SMARK and causes a TRA 2,4 return to MARK.

CALL ON (N) turns trigger N on.

CALL OFF (N) turns trigger N off.

The order of the differences to be carried in the Adams-Moulton integration must be stored in HBAND(1), the nominal step size in HBAND(4), the maximum number of equations allowable in HBANK(5), and all independent and dependent variables initialized before calling SMARK. The double precision part of the independent variable HBANK(7) is set to zero by SMARK.

Subroutine MARK

MARK is a closed subroutine designed to solve the first n of a set, N, of first-order differential equations utilizing Adams-Moulton open or open and closed formula types. A Runge-Kutta fourth-order integrator is used as a starting routine to generate backward differences initially. Provision is made for interrupting the integration process at specific values of either the independent or the dependent variables. The order of differences (m) used in the Adams-Moulton mode is less than or equal to nine (9) ($m \leqslant 9$).

Restrictions.- The following restrictions to subroutine MARK apply:

(1) MARK will not integrate backwards in the independent variable. The nominal step size, H, must be positive. Changes in H must be accomplished by the use of a "doubling" or "halving" procedure in MARK that will double (set H = 2H) or halve (set H = 0.5H) the integration step size.

(2) Underflow and overflow are not checked internally.

(3) The user must provide the necessary interruption subroutines, an auxiliary program to evaluate the n first-order derivatives, and a bank of storage for internal calculation.

(4) This is an FAP program and is not FORTRAN compatible.

Integration technique.- The following integration technique applies:

(1) MARK permits the user to solve the N differential equations by one of three options:

   a. Runge-Kutta fourth order.

   b. Adams-Moulton with a fixed step size, H, and the ability to alter H by the doubling and/or halving procedure using Runge-Kutta to initially generate backward differences. This applies to either a predictor or a predictor with q corrections (open or open and closed type formulas).

   c. Adams-Moulton as mentioned in b. using an automatic variable step size control. Halving and doubling are controlled automatically. The correction formula is applied only once.

(2) Both the independent and the dependent variables are automatically carried internally in partial double precision to control round-off error locally. The user, however, will recognize the variables only as single precision quantities. However, the user may carry the independent variable in full double precision by option.

Usage of MARK.- The following usage of MARK applies:

Calling Sequence:

```
CALL MARK or TSX $MARK,4

PZE HBANK, P, EOS

PZE DERI, φ, DER2

ERROR RETURN

Pfx B1,,Y1

PZE Z1

Pfx B2,,Y2

PZE Z2

.

.

.

Pfx BJ,,YJ

PZE ZJ

PZE O
```

where the symbols are defined as follows:

HBANK - The location of a bank of storage to be described below.

O - The independent variable is carried in partial precision.

P - double precision (single precision to the user).

1 - The independent variable is carried in full double precision.

EOS - The location of a user "end of step" routine. This routine must terminate with a TRA 1,4 command. It is used to evaluate variables that are needed only after a full integration step is completed.

DER1 - The location of the entry to the user's derivative routine that carries out all calculations that involve the independent variable. This routine must terminate with a TRA 1,4 command.

DER2 - The location of the entry to that portion of the user's derivative routine that carries out all calculations that do not involve the independent variable but are required to evaluate the derivatives.

A simple example of the use of DER1, DER2 follows:

Suppose we are to solve

$$\frac{dy}{dx} = ax^2 + by$$

then

$$\text{DER1 } ax^2$$

Thus, the DER1 entry calculates the extra term involving the independent variable x. This provides a saving of real machine time, particularly during the Runge-Kutta phase of integration, and also saves machine time when the closed type formula is used with Adams-Moulton integration.

0 - Adams-Moulton integration with fixed step size

ϕ = 2 - Runge-Kutta integration only

4 - Adams-Moulton using automatic variable step size control

The pairs of locations in the calling sequence are specified as:

Pfx BJ,,YJ

PZE ZJ are defined as "triggers"

These triggers are the linkage control to the user's interruption subroutines. The triggers state that control is transferred to location BJ when the contents of location YJ are equal to the contents of location ZJ. Thus BJ is the location of a user's interruption subroutine, YJ is the location of a variable being checked, and ZJ is the location that contains the desired value for YJ.

Triggers are separated into two classes: Independent variable triggers called T-stops and dependent variable triggers called Y-stops.

(1) Independent variable triggers called T-stops. These triggers interrupt on values of the independent variable of integration. All T-stops must have YJ = 0. That is, they must have the following format in the calling sequence:

Pfx BJ

PZE ZJ

The logic used to execute T-stops is as follows:

Let $t_{s1}, t_{s2}, t_{s3} \ldots\ldots t_{sk}$ be a set of values of the independent variable for which interruptions are desired.

MARK sets $t_m = \text{Min} \; [t_{s1}, t_{s2}, \ldots\ldots t_{sk}]$. Integration continues normally until the independent variable reaches the condition:

$$t_\eta < t_m \leqslant t_\eta + 1$$

The step size is set = $(t_{\eta + 1} - t_m)$ and integration is carried to t_m where all the values of the variables including derivatives and end of step values are calculated and control is then transferred to the user's interruption routine, all values are reset to station $t_{\eta-1}$ and the next t_m is determined. If no other t_m exists within this step, integration continues. Thus, interruption routines for all t_m within a given step are executed before integration continues. There is no limitation on the number of T-stops permitted (except for machine size, of course).

(2) Dependent variable triggers called Y-stops. These triggers are interrogated at the beginning of an integration step and a value.

$$i_j = y_\eta = y_j$$

is calculated and saved for each of the j Y-stops. At the end of the integration step the difference,

$$r_j = y_{\eta + 1} - y_j$$

is calculated and the algebraic sign of r_j is compared to l_j:

If

$$\text{sgn } l_j \neq \text{sgn } r_j$$

then the condition $y = y_j$ has occurred within the integration step and a linear interpolation search procedure is executed to determine the value of the independent variable, t, such that $y = y_j$. When the Δt calculated by the search procedure is such that

$$\Delta t < \delta_u$$

where

$$\delta_u = \begin{cases} 2^{-26} \text{ Max } H, t_{\eta + 1} & \text{for } P = 0 \\ 2^{-42} \text{ Max } H, t_{\eta + 1} & \text{for } P = 1 \end{cases}$$

then convergence to t_j is assured. At this point all values of the dependent variable including their respective derivatives and any end-of-step calculations are determined and control for the corresponding Y-stop is returned to the user's interruption routine. If more than one Y-stop trigger occurs within an integration step, then the triggers are executed in the order of the smallest value of the independent variable determined for the respective Y-stops. Thus, the order of execution is determined by the independent variable. After all Y-stops within an integration step have been determined and executed, the conditions at station $t_{\eta + 1}$ are restored for all dependent variables and their derivatives and end-of-step calculations, if any. Integration then continues normally.

Up to and including 50 dependent variable triggers are permitted. However, this number may be altered by changing the symbolic card "OMAR EQU 50" in the symbolic program deck to the desired number.

It remains to define Pfx of the trigger pair. This is utilized to permit the user to render triggers "active" or "inactive". Active means that a trigger is to be interrogated and executed if necessary. Inactive means that the trigger is to be ignored.

Thus, if

$$\text{Pfx} = \begin{array}{l} \text{PZE = trigger is active} \\ \text{MZE = trigger is inactive.} \end{array}$$

The interruption routines provided by the user must terminate with either a TRA 1,4 command or a TRA 2,4 command.

TRA 1,4 is used when the interruption does not constitute a discontinuity in any of the calculations.

TRA 2,4 is used when a discontinuity exists. Under this condition a "restart" procedure is initiated by MARK by continuing beyond the discontinuity point using Runge-Kutte until a sufficient number of backward differences are determined to switch to Adams-Moulton integration.

Comments on triggers.- The following are comments on triggers:

(1) There is no limitation on how many times a trigger may be executed.

(2) Care must be exercised in updating the ZJ of triggers. If the ZJ are not updated after a trigger returns control to the user, a machine loop will result, since MARK will continue to return control to the user, a machine loop will result, since MARK will continue to return control to the user's respective interrupt routine on the basis of the current ZJ. Thus, a trigger must either be updated or rendered inactive to looping.

(3) In all cases where more than one trigger is to be executed at a single point (t_j) the triggers will be executed in order of their ascending appearance in calling sequence

(4) Control is returned to the error return of the calling sequence whenever $t_m < (t_\eta - \delta_u)$ or when the number of Y-steps exceeds 50.

The entire list of triggers must be terminated with PZE 0. This is the end of the calling sequence for MARK.

The bank of storage specified by the location HBANK is as follows:

```
        PZE m

        PZE NH

        PZE ND

HBANK

        DEC H

        PZE N,,n

        DEC t1

        DEC t2
```

```
DEC y_1
DEC y_2
.
.
.
DEC y_n
.
.
.
DEC y_N
DEC y'_1
DEC y'_2
.
.
.
DEC y'_n
.
.
.
DEC y'_N
.              3N + 2N(m + 1)  for φ 0,2
BSS
                5N + 3N(m + 2)  for φ 4
```

where

m = order of differences to be carried in the Adams-Moulton mode.

$m \leqslant 9$ (fixed point in the address portion of the word) for $\phi = 0$.

$m \leqslant 8$ for $\phi = 4$.

NH = number of times to sequentially halve the step size in the Adams-Moulton mode (fixed point in the address portion of the word).

NOTE

NH takes precedence over ND and doubling is not executed until the number of times to halve is completed. If these numbers are introduced initially in the HBANK, the procedure is commenced automatically when conversion from Runge-Kutta to Adams-Moulton is completed. NH and ND are ignored when using the automatic variable step size mode. NH and ND may be set by dependent variable or independent variable interruption routines in the Adams-Moulton fixed mode. Control is returned to the user anytime through an interruption routine. The number of times halving and/or doubling have/has been completed is available in the decrement portion of NH and/or ND. If additional halving and/or doubling requests are entered in the address portions of NH and/or ND before a preceding request is completed, the sum of the additional request and those remaining uncompleted will be executed.

H = nominal step size (floating point).

N = total number of 1st order differential equations (fixed point).

n = total number of the first n 1st order differential equations to be integrated by MARK. $n \leqslant N$ (fixed point).

NOTE

H and N must not be altered unless a restart procedure is executed after

the inital entry to MARK. Item n may be altered after the inital entry to MARK through an interruption routine. If n is increased, MARK restarts. Care should be exercised in setting the initial conditions corresponding to the additional equations to be integrated. If n is decreased, MARK continues normally integrating the new n set of differential equations.

t_1 = single precision value of the independent variable in floating point.

t_2 = double precision value of the independent variable in floating point. This must be zero initially if P = 0 (single precision).

y_1 to y_N — values of the N differential equations for the dependent variables. The initial or starting values must be predetermined and set by the user (floating point).

y'_1 to y'_N — values of the derivatives of the dependent variables calculated and stored by the user's derivative routine (DER1, DER2). An initial pass is executed through DER1, DER2, and EOS by MARK before the integration process is commenced (floating point).

<u>MARK entry points</u>.- Provision is made through entry points to MARK to transmit certain information to MARK or to render certain information available to the user that is stored internally in MARK:

HC By using the command

```
CLA* $HC
```

the user has direct access to the current step size being used in the integration process. This is not necessarily the nominal step size, H, introduced by the user in the HBANK (floating point).

NI By using the command

```
STO* $NI
```

the user informs MARK that he desires i corrections to be performed on the predictor formula used in the Adams-Moulton fixed mode of integration. See Mathematical Description in this Appendix for description of the predictor-corrector formulas being used. In the automatic step size control mode i is automatically 1, and MARK ignores NI. Thus 1 correction is made for each prediction in this mode (fixed point).

TGLO By using the command

CLA* $TGLO

The user has direct access to the most recent $t_{\eta} + 1$ calculated, where $t_{\eta} + 1$ represents the value of the independent variable at the end of an integration step (floating point).

Y The command

CLA* $Y

gives the user access to the location of the dependent variables (single precision) in the HBANK. This appears as L(Y), where index register 1 set to n and counted down renders all the variables to the user (floating point).

YDOT The command

CLA* $YDOT

Y(2) performs the same function as Y for the derivatives of the dependent variables (floating point).

The command

CLA* $Y(2)

renders the location of the double precision part of the dependent variables available to the user

YO (floating point).

The commands

CLA* $YO

CLA* $YO(2)

render the locations of the single and double precision values of the dependent variables at t_η available to the user. Item t_η represents the value of the independent variable at the beginning of an integration step (floating point).

The following symbols refer to entry points used for the automatic step size mode.

EUBAR The command

STO* $EUBAR

stores $\overline{E}$ for use in automatic error control (floating point).

ELBAR The command

STO* $ELBAR

stores $\underline{E}$ in floating point for use with AEC.

HMAXT

STO* $HMAXT

stores maximum allowable H for AEC (automatic error control) (floating point).

HMINT

STO* $HMINT

stores minimum allowable H for AEC in floating point.

YCLOW

STO* $YCLOW

stores $\underline{Y}$ for AEC in floating point.

RGERR

CLA* $RGERR

permits access to the maximum $E_\eta + 1$ for the user in floating point.

NOTE

EUBAR through YCLOW are consecutive locations in MARK.

Space required.- MARK requires $3453_8 = 1835_{10}$ storage locations. No COMMON is required. The user must supply

$$5N + 7 + 2N(m + 1)$$

storage locations for $\phi = 0,2$ or $7N + 7 + 3N(m + 2)$ for $\phi = 4$. N = maximum number of differential equations; m = order of differences to be carried in the Adams-Moulton mode. $\phi = 0,2$ is for Runge-Kutta integration or for Adams-Moulton integration in the fixed mode. Also, whatever storage is required for the user's derivative box and trigger control must be supplied.

Timing information.- MARK will do approximately 40 integration intervals per second. (This time was obtained from solving a set of 14 first-order differential equations.)

Checkout.- MARK has been checked out rather extensively using a variety of programs at the Jet Propulsion Laboratory. These programs include the JPL tracking program, a low thrust trajectory program, and a program of a general nature that solves a system of differential equations starting with five equations, repeating these five and adding sets of five with repetition until a maximum of thirty equations have been reached and integrated.

Mathematical Description

The classical Runge-Kutta fourth-order equations.- Let the system of equations to be solved be in the form,

$$y_j' = f_j\,(t,\ y_1 y_2, \ldots, y_n) \quad j = 1, 2, \ldots, N$$

Let $y_{j,\eta}$ be the value of y_j at $t = t_\eta$ and $f_{j,\eta}$ be the derivative of y_j at $t = t_\eta$. Let h be the step size of the independent variable t. Then,

$$K_1 = h\, f_j(t_\eta , y_{j,\eta})$$

$$K_2 = h\, f_j(t_\eta + 1/2\, h,\ y_{j,\eta} + K_1/2)$$

$$K_3 = h\, f_j(t_\eta + 1/2\, h,\ y_{j,\eta} + K_2/2)$$

$$K_4 = h\, f_j(t_\eta + \Delta t,\ y_{j,\eta} + K_3)$$

$$y_{j,\eta + 1} = y_{j,\eta} + 1/6\,(K_1 + 2K_2 + 2K_3 + K_4)$$

<u>The Adams-Moulton predictor-corrector equations</u>.- Let y_j, y_j' be defined as above. Then,

$$Y^P_{j,\eta+1} = y_{j,\eta} + h(a_o\nabla^o + a_1\nabla^1 + \ldots + a_m\nabla^m)\, y_j'$$

(open type)

where ∇ is a backward difference operator operating on $y'_{j,\eta}$ and

$$\nabla^o y'_{j,\eta} = y'_{j,\eta}$$

The predictor coefficients a_m are:

$a_o = 1.0$

$a_1 = 0.5$

$a_2 = 0.416666666$

$a_3 = 0.375$

$a_4 = 0.348611111$

$a_5 = 0.329861111$

$a_6 = 0.315591936$

$$a_7 = 0.304224539$$

$$a_8 = 0.294868003$$

$$a_9 = 0.2870754484$$

$$y'^{P}_{j,\eta+1} = f_j(t_\eta, y_j) \quad j = 1, \ldots, N$$

$$y^{1}_{j,\eta+1} = y_{j,\eta} + h(b_o\nabla^o + b_1\nabla^1 +, \ldots, + b_m\nabla^m)\, y'^{P}_{j,\eta+1}$$

where Δ is defined as above, 1 is the first corrector application, and the corrector coefficients b_m are:

$b_o = 1.0$	$b_5 = -0.01875$
$b_1 = -0.5$	$b_6 = -0.0142691795$
$b_2 = -0.0833333333$	$b_7 = -0.0113673950$
$b_3 = -0.0416666666$	$b_8 = -0.0093565362$
$b_4 = -0.0263888888$	$b_9 = -0.0078925542$

NOTE

$$b_{m+1} = a_{m+1} - a_m$$

continuing

$$y^{2}_{j,\eta+1} = y_{j,\eta} + h(b_o\nabla^o + b_1\nabla^1 + \ldots + b_m\nabla^m)\, y'^{1}_{j,\eta+1}$$

$$y_{j,\eta+1}^{(i+1)} = y_{j,\eta+1}^{(i)} + h\,\sigma\,\epsilon^{(i)}$$

where

$$\sigma = \sum_{\ell = 0}^{m} b_m \quad ; \quad \epsilon^{(i)} = y'_{j,\eta + 1}{}^{(i-1)}$$

i is the i^{th} correction on the predictor formula.

<u>The formula for interpolation to interrupt on a dependent variable in the Adams-Moulton mode</u>.- The following formula applies:

$$q_j = (-)^q \left| \begin{matrix} \mu \\ j \end{matrix} \right| \text{ where } \mu = \frac{t_{\eta + 1} - t_\mu}{h_c} \geq 0$$

and

$$\left| \begin{matrix} \mu \\ j \end{matrix} \right| = \frac{(\mu-1)\,(\mu-2)\,\ldots\,(\mu-j)}{(j + 1)!} \quad j = 1, \ldots, m$$

$$c_j = b_j + \sum_{i=0}^{j} q_i b_{j-i} \quad j=1,\ldots,m$$

b_j = corrector coefficients described in 2 above.

$$d_j = c_j^{\,j} \quad j = 1,\ldots,m$$

$$y_{\ell,\mu} = y_{\ell,\eta + 1} - h\mu\,(y'_{\ell,\eta + 1} + \sum_{j=1}^{m} d_j)\ \ell = 1,\ldots,n$$

Figure A-1 describes the configuration.

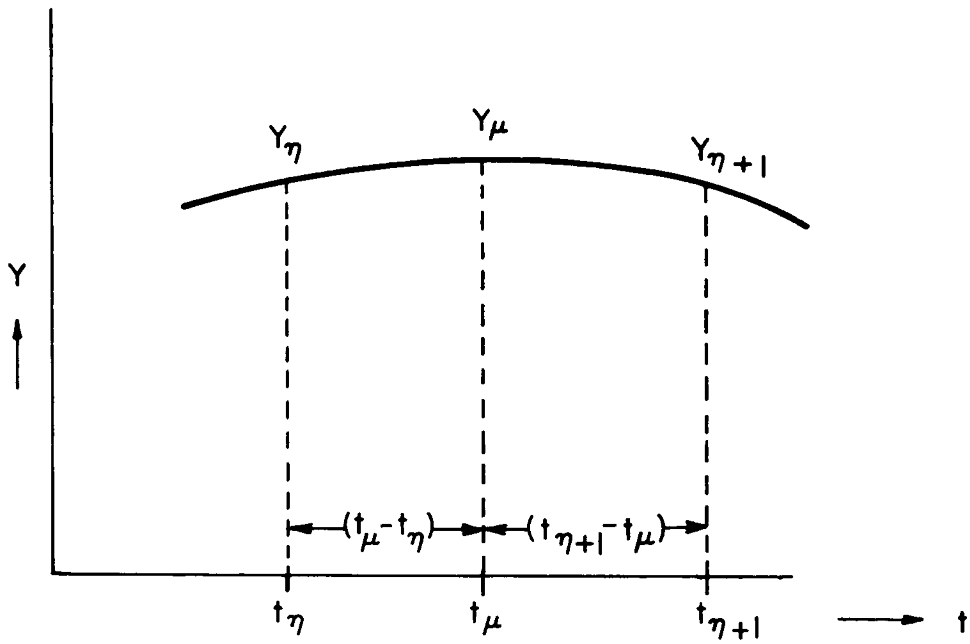

Figure A-1.- Plot of y versus t

The formula for interpolation to halve the step size (H), dropping the subscript j.- The following formula applies:

$$y'(\bar{t}) = \sum_{k=0}^{m} q_{-k}^{(m)}(\mu)\, y'(t_{\eta-k})$$

where

$$q_{-k}^{(m)}(\mu) = \frac{1}{m!} \prod_{i=1}^{m} (i + \mu)$$

$$\bar{t} = t_\eta - n\ell h \quad n = 1, 2, \ldots ; \ \ell = 1/2, 1/3, \ldots$$

$$\mu = \frac{t_\eta - n\ell h - t_\eta}{h} = -n\ell$$

Let $\ell = 1/2$, then $\mu = -1/2$ where n represents the absolute value of the subscript of $\bar{t}$ in Figure A-2.

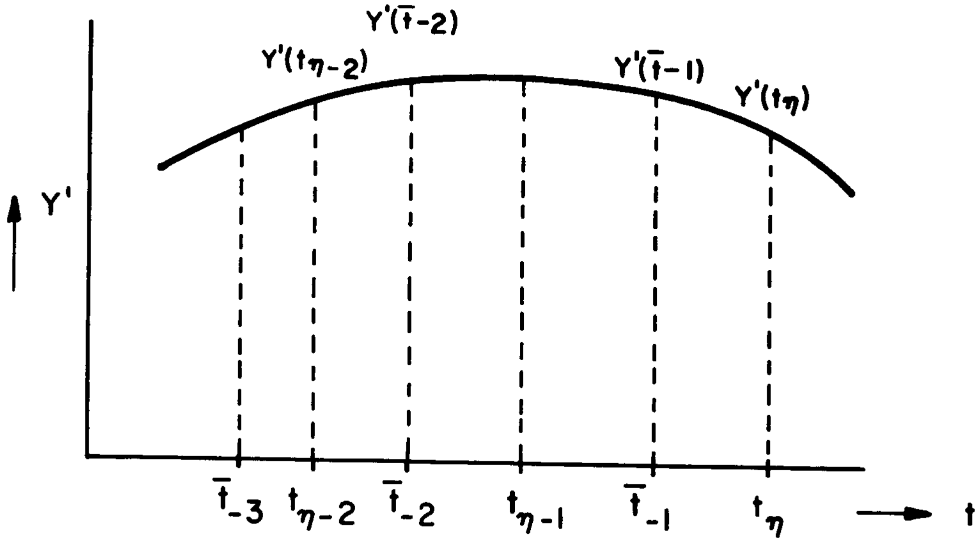

Figure A-2.- Plot of y' versus t

In the program:

$$q_o = \frac{1}{m!} \prod_{i=1}^{m} (i + \mu) \text{ and } q_{k+1} = q_k \frac{(\mu + k)(m - k)}{(\mu + k + 1)(k + 1)}$$

where k is the absolute value of the subscript of t in Figure A-2.

Automatic step-size control.- The following denotes automatic step-size control:

$$E_{\eta + 1} = \text{MAX} \left| \frac{y^P_{j,\eta + 1} - y^c_{j,\eta + 1}}{A D_j} \right|$$

where

$$A = \left| \frac{a_m}{b_{m + 1}} \right| ; \quad D_j = \text{MAX} \left| y^c_{j,\eta + 1} \underline{y} \right|$$

The expression $E_{\eta + 1}$ represents the maximum error in any of the dependent variables in the final iterate $y_{j,\eta + 1}$ due to truncation error in the step from t_η to $t_{\eta + 1}$. The user, through the entry points, supplies MARK with a set of values to be described as follows:

(1) $\bar{E}$ - upper bound on the truncation error $E_{\eta + 1}$.

(2) $\underline{E}$ - lower bound on the truncation error $E_{\eta + 1}$.

(3) h_{max} - maximum allowable value of the step size.

(4) h_{min} - minimum allowable value of the step size.

(5) y - a constant used to prevent unnecessary reduction whenever $|y_{j,\eta + 1}|$ is small. $\underline{y} > 0$.

The step size, h, is doubled, left alone, or halved depending on the following inequalities:

(1) If $E_{\eta + 1} \leqslant \bar{E}$ for m successive steps, the step size, h, is set = 2h.

(2) If $\underline{E} < E_{\eta + 1} \leqslant \bar{E}$, the step size, h, is left alone.

(3) If $E_{\eta + 1} > \bar{E}$, the step size, h, is set = 1/2 h.

The program preserves all the conditions y_j, $\nabla_j^{m + 1}$ at t_η and integrates to $t_{\eta + 1}$.

If (1) holds, then MARK sets up the doubling procedure and integrates m + 1 more steps checking that (1) holds at each step. If (1) holds, the doubling procedure is completed and h = 2h.

If (2) holds, integration continues normally.

If (3) holds, then MARK restores $y_{j,\eta}$, $\nabla_{j,\eta}^{m + 1}$, t_η, $y'_{j,\eta}$. It executes the end of step box to restore those values at t_η. Finally, the halving procedure is executed and h = 1/2 h. Thus, it is never necessary on the basis of error control to restart the integration procedure in the Runge-Kutta mode. Item $\bar{E}$ is approximately equivalent to specifying the number of significant figures to preserve locally throughout the integration. Item $\bar{E}$ should normally range from 10^{-8} to 10^{-3}. $\underline{y}$ may be determined by the user but should probably range from 10^{-5} to 1.

APPENDIX B

COMPUTER PRINTOUT

```
MAIN       - EFN   SOURCE STATEMENT  -  IFN(S)  -                02/06/69          PAGE  1

      COMMON /DATA/ RMAX,      RMIN,      TMAX,      TMIN,      PMAX,      MAIN0003
     1                PMIN,      PRNT,    RELERR,       AO,        BO,      MAIN0004
     2                  RO,   THETAO,      PHIO,      PLUS,   NPOWER,      MAIN0005
     3               NPLOT,        J,      NUAR,        N1,       FN,      MAIN0006
     4                DNDR,     DNDT,      DNDP,       EMU,   PTYSQR,      MAIN0007
     5                   F,       F2,        C1,        FH,   COSPSI,      MAIN0008
     6              SINPSI,    DFHDR,     DFHDT,     DCPDT,   DCPDY1,      MAIN0009
     7              DCPDY2,   DCPDY3,       SP2,    EMUINT,     EMUS,      MAIN0010
     8                  N,       GNU,    MUFLAG,    NTEST                   MAIN0011
      COMMON  /HBANK1/ MORDER,     NOHALF,    NODOUB,    HBANK,    NOEQ,   MAIN0012
     1                 FINVP,     FINVPI,    YO(11),    YD(11),  MA(260)MAIN0013
      COMMON /CKSR/ C,RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,YO6             MAIN0014
      COMMON /NEW/ PLOTO,ROOT                                              MAIN0017
      COMMON/EPSTN/EPSTIN,PROPT                                            MAIN0018
      COMMON /RSN/ IRSN
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,FIT,DNMNTR,DEL2S              MAIN0019
      COMMON /POWLOS/  COSA,        Y,      DMDR,      DMDT,      DMDP,    MAIN0020
     1                 DMDY1,    DMDY2,     DMDY3,     DMDSI,    DMDDSI,   MAIN0021
     2                 DMUDR,    DMUDT,     DMUDP,    DMUDY1,    DMUDY2,   MAIN0022
     3                DMUDY3,   DMUDSI,      EMU,     EMRAD                 MAIN0023
      DIMENSION  DATE(04) ,   PLT(15)
      DIMENSION  DD(3002) , SOA(3002)
      COMMON / RECT  /    DU ,  SOA , LB
      COMMON / ROOTS /  JUMP , NYD1
C                                                                          MAIN0026
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLO4,HMAXI,HMINT,KD              MAIN0016
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /GRAPHO/  XMAXO ,XMINO ,YMAXO ,YMINO , PLT
C                                                                          MAIN0015
      DATA  PI  , PI02  / 3.1415927 , 1.5707963 /
      DATA  PI2 , RAD   / 6.2831853 , 0.0174533 /
  102 NTEST = 0                                                            MAIN0028
      J = 0
      N1=0                                                                 MAIN0029
      NOEQ = 11                                                            MAIN0030
      KD=4                                                                 MAIN0031
   39 CONTINUE
C
      NYD1  =  0
      IRSN  =  0
      LB    =  0
      ND    =  0
      N     =  0
C
  104 CALL INPUT                                                           MAIN0042
C                                                                          MAIN0041    12
      IF( IRSN .EQ. 1 ) GO TO 39
C
      PRNTO=PRNT                                                           MAIN0043
      PLOTT = PLOTO                                                        MAIN0044
      MORDER = ORDER                                                       MAIN0045
      TESTJ=HBANK                                                          MAIN0046
C
      DO 20 I1 = 1,10                                                      MAIN0048
   20 CALL ON(I1)                                                          MAIN0049    22
```

```
      MAIN         - EFN    SOURCE STATEMENT  -  IFN(S)  -          02/06/69                    PAGE
  105 CALL OFF(9)                                                    MAIN0050
C                                                                             27
      MUFLAG = 0                                                     MAIN0047
      FINVP=0.                                                       INPU0074
      FINVPI=0.                                                      INPU0075
      NUAR=10                                                        MAIN0051
      PROPT=1.                                                       MAIN0052
C
 1047 CALL SMARK(KD,NUAR,MORDER,NRTN,NTRG,EUBAR,ELBAR,HMAXT,HMINT,YCLOW,MAIN0053
     1FINVP,PRNTO,YO(1),PMAX,YO(1),RMIN,YO(2),TMAX,YO(2),TMIN,YO(3),PMAXMAIN0054
     1,YO(3),PMIN,FINVP,TESTJ,YD(1),RDOT,FINVP,PLOTT  )              MAIN0055
C                                                                             32
  106 GO TO (40,41,41,42,43),NRIN                                    MAIN0056
C
   41 C=COS(YO(2))                                                   MAIN0057    35
      RCT=YO(1)*C                                                    MAIN0058
      S=SIN(YO(2))                                                   MAIN0059    36
      RST=YO(1)*S                                                    MAIN0060
      YSQUAR = 0.0
      DO 50  I = 4,6
      YADD   =  YO(I)
      YSQUAR = YSQUAR  + YADD * YADD
   50 CONTINUE
      RTYSQR  = SQRT( YSQUAR )
C                                                                             44
  107 CALL DENSE                                                     MAIN0063    46
      X     = EN / C1
      TERM = 1. - X
C
C     TEST IF VALUE OF TERM IS ABNORMAL
C
      IF( TERM ) 2000,2000,2001
 2000 WRITE(6,2002) TERM                                                          49
 2002 FORMAT(13H MAIN TERM = ,E15.5 )
      GO TO 4001
 2001 CONTINUE
C
  108 CONTINUE
      TERM2 = TERM * TERM
C
      CALL COLL( YO(1),YO(2),YO(3),GNU )
C                                                                             53
      Z = GNU/F * .1591549E-6                                        MAIN0069
  110 CALL FIELD                                                     MAIN0070
C                                                                             56
      Y      =  FH / F
      YT     =   Y * SINPSI
      YT2    =  YT * YT
      YL     =   Y * COSPSI
      YL2    =  YL * YL
      YLYT   =  YL * YT
C
      EM     =  0.5 * YT2 / TERM
      EMRAD =  PLUS * SQRT( EM* EM + YL2 )                                        58
      EMD   =  1. - EM + EMRAD
      EMUS  =  1. -  X / EMD
```

```
C
C     TEST IF VALUE OF EMUS IS ABNORMAL
C
      IF( EMUS ) 2003,2003,2004
 2003 WRITE(6,2005) EMUS                                        60
 2005 FORMAT(13H MAIN EMUS = ,E15.5 )
      GO TO 4001
 2004 CONTINUE
C
  116 EMU=SQRT(EMUS)                                  MAIN0082
C
  117 CALL FORCE                                      MAIN0083    64
C
  118 DMD=F2*TERM                                     MAIN0084    66
      DMN1=FH*SP2                                     MAIN0085
      DMN2=COSPSI*FH**2                               MAIN0086
      DMT1=EM/12400.                                  MAIN0087
      DMT2=-DMN2/DMD                                  MAIN0088
      DMUN1=YL2/FH                                    MAIN0089
      DMUN2=YL2/COSPSI                                MAIN0090
      DMD1=EMU/.5*EMD                                 MAIN0091
      DMUD1=C1*DMD1                                   MAIN0092
  119 DMUN3=X/DMD1/EMD                                MAIN0093
C                                                     MAIN0094
C     COMPUTE DERIVATIVES OF M                        MAIN0095
C                                                     MAIN0096
  120 DMDR=(DMN1*DFHDR-DMN2*DCPDR+DMT1*DNDR)/DMD      MAIN0097
      DMDT=(DMN1*DFHDT-DMN2*DCPDT+DMT1*DNDT)/DMD      MAIN0098
      DMDP=(DMN1*DFHDP-DMN2*DCPDP+DMT1*DNDP)/DMD      MAIN0099
      DMDY1=DMT2*DCPDY1                               MAIN0100
      DMDY2=DMT2*DCPDY2                               MAIN0101
      DMDY3=DMT2*DCPDY3                               MAIN0102
  121 DMDF=-Y12/F*1.E-6/TERM2                         MAIN0103
C                                                     MAIN0104
C     COMPUTE DERIVATIVES OF MU                       MAIN0105
C                                                     MAIN0106
  122 DMUDR=(EN*((EM*DMDR+DMUN1*DFHDR+DMUN2*DCPDR)/EMRAD  MAIN0107
     1-DMDR)/EMD-DNDR)/DMUD1                          MAIN0108
      DMUDT=(EN*((EM*DMDT+DMUN1*DFHDT+DMUN2*DCPDT)/EMRAD  MAIN0109
     1-DMDT)/EMD-DNDT)/DMUD1                          MAIN0110
      DMUDP=(EN*((EM*DMDP+DMUN1*DFHDP+DMUN2*DCPDP)/EMRAD  MAIN0111
     1-DMDP)/EMD-DNDP)/DMUD1                          MAIN0112
      DMUDY1=((EM*DMDY1+DMUN2*DCPDY1)/EMRAD-DMDY1)*DMUN3  MAIN0113
      DMUDY2=((EM*DMDY2+DMUN2*DCPDY2)/EMRAD-DMDY2)*DMUN3  MAIN0114
      DMUDY3=((EM*DMDY3+DMUN2*DCPDY3)/EMRAD-DMDY3)*DMUN3  MAIN0115
  123 DMUDF = (EMD/F * 2.E-6 - DMDF + (EM*DMDF -YL2/F * 1.F-6)/EMRAD)*  MAIN0116
     1        DMUN3                                   MAIN0117
C                                                     MAIN0118
C     COMPUTE KAPPA                                   MAIN0119
C                                                     MAIN0120
  124 EMZ = YT2/(TERM2 + Z**2)*.5                     MAIN0121
      A=EMZ*TERM                                      MAIN0122
      B=EMZ*Z                                         MAIN0123
      U=A**2-B**2+YL2                                 MAIN0124
      V = A/.5 * B                                    MAIN0125
      W = .5*(U + SQRT(U**2 + V**2))                  MAIN0126    74
```

```
      W = SQRT( ABS(W) )                                      MAIN0128   75
      A=1.-A+PLUS*W                                           MAIN0129
      B=Z+B-PLUS/W*V/2.                                       MAIN0130
  125 CAPPA=F/EMU*B/(A**2+B**2)*X/.095492                     MAIN0131
C                                                             MAIN0132
C    COMPUTATION OF EPSTEIN CONDITION                         MAIN0133
C                                                             MAIN0134
  126 EPSTIN=B*X/(A**2+B**2-A*X)                              MAIN0135
C                                                             MAIN0136
C     COMPUTE COS(ALPHA)                                      MAIN0137
C                                                             MAIN0138
  127 DMDSI=YLYT/TERM                                         MAIN0139
      DMDUSI=(EM*DMUSI-YLYT)/EMRAD-DMUSI                      MAIN0140
      DMUDSI=DMUDSI*DMUN*                                     MAIN0141
  128 COSA=EMU/SQRT(EMUS+DMUDSI**2)                           MAIN0142
C                                                             MAIN0143
C     COMPUTE DERIVATIVES OF RAY COORDINATES                  MAIN0144
C                                                             MAIN0145   80
  129 YD(1)=(YO(4)-EMU*DMUDY1)/EMUS                           MAIN0146
      YD(2)=(YO(5)-EMU*DMUD(2)/EMUS/YO(1)                     MAIN0147
      YD(3) = (YO(6)  - EMU*DMUDY3)/EMUS/RST                  MAIN0148
      YD(4) = DMUDR/EMU + YD(2)*YO(5) + YD(3)*YO(6)*S         MAIN0149
      YD(5)  = (DMUDT/EMU - YD(1)*YO(5) + YD(3)*YO(6)*RCT)/YO(1) MAIN0150
      YD(6) = (DMUDP/EMU - YO(6)*(YD(1)*S+YD(2)*RCT))/RST     MAIN0151
      YD(7)=1.+F*1.E6/EMU*DMUDF                               MAIN0152
      YD(8)=1./EMU/COSA                                       MAIN0153
      YD(9)=-CAPPA/EMU*YO(9)                                  MAIN0154
C                                                             MAIN0155
C      TO COMPUTE THE DOPPLER SHIFT USING JONES METHOD        MAIN0156
C                                                             MAIN0157
  130  YD(10)=DMUDP/EMU                                       MAIN0158
  131 IF(NPOWER.NE.0) CALL POWERL                             MAIN0159   85
   40 CALL TRA14                                              MAIN0160
C
C                                                                        88
   42 IF (NTRG .EQ. 3 .AND. J .EQ. 2 ) NTRG = 11              MAIN0163
  132 CALL OUTPUT(NTRG)                                       MAIN0164   93
  133 GO TO (44,39,39,39,39,39,39,45,908,47,46 ) , NTRG       MAIN0165
   44 PRNTO=PRNTO+PRNT                                        MAIN0166
      CALL TRA14
C
C                                                                        96
  908 IF ( NYD1 - 2 )4000,4001,4001
 4001 CALL OUTPUT(1)                                                     100
      JUMP = 2
      CALL OUTPUT(10)                                                    103
      GO TO 39
 4000 CALL TRA14
C
C                                                                        106
   47 PLOTT = PLOTT + PLOTO                                   MAIN0168
      CALL TRA14                                              MAIN0169
C
C                                                                        108
   45 CALL ON(3)                                              MAIN0170   110
  134 CALL OFF(8)                                             MAIN0171   112
```

```
 135 CALL ON(9)                                              MAIN0172   114
 136 IF(NPOWER.EQ.1.AND.NUAR.EQ.10) GO TO 1046               MAIN0173
     CALL TRA14                                              MAIN0174
C
C     COMPUTE POWER LOSS IN NEAR FIELD
C
1046 NUAR=11                                                            118
     HBANK=.001                                              MAIN0175
     THETA=THETAU*RAD                                        MAIN0176
 137 EMUPI=EMUINT*PI                                         MAIN0177
C                                                            MAIN0178
     CALL CSINT(EMUPI,CIMUPI,SIMUPI)
     CALL CSINT(EMUINT*PI2,CIM2PI,SIM2PI)                               122
C
 140 EMUPI2=EMUINT*PI02                                                 124
     DENOM=.5772+ALOG(EMUPI)-CIMUPI+SIN(EMUPI)/2.*(SIM2PI-2.*SIMUPI)  MAIN0181
    1  +COS(EMUPI)/2.*(.5772+ALOG(EMUPI2)+CIM2PI-2.*CIMUPI)  MAIN0182
     COSPSI=SIN(THETA)*SIN(YO(2))*COS(PHIO*RAD-YO(3))        MAIN0183   126  127  128  129
    1  +COS(THETA)*COS(YO(2))                                MAIN0184
     RO2=RO**2                                               MAIN0185   130  131  132  133  134
     R2=YO(1)**2                                             MAIN0186
     RP2=R2+RO2-2.*RO*YO(1)*COSPSI                           MAIN0187
     RP=SQRT(RP2)                                            MAIN0188
     PSI=PI-ARCOS((RP2+RO2-R2)/(2.*RP*RO))                   MAIN0189   135
 141 PROPT=((COS(EMUPI2*COS(PSI))-COS(EMUPI2))/SIN(PSI))**2  MAIN0190   136
    1  /(PI2*RP2*DENOM)*.7161972E-2/F2/EMUINT                MAIN0191
     GO TO 1047                                              MAIN0192   138  139  140  141
C                                                            MAIN0193
C
  46 YO(4) = -YO(4)
 142 YO(10) = 0.                                             MAIN0194
 143 CALL OFF(3)                                             MAIN0195
 144 CALL ON(8)                                              MAIN0196   146
 145 TESTJ = PRNTO + PRNT                                    MAIN0197   148
 146 CALL TRA24                                              MAIN0198
C                                                            MAIN0199
C
  43 WRITE(6,1000)                                                      151
     STOP                                                    MAIN0200   152
1000 FORMAT(24H1 ERROR RETURN FROM MARK)                     MAIN0202
     END                                                     MAIN0203
```

$IBFTC INPU

```
      SUBROUTINE INPUT
      COMMON /DATA/ RMAX,      RMIN,     TMAX,     TMIN,     PMAX,      INPU0003
     1              PMIN,      PRNT,     RELERR,   AO,       RO,        INPU0004
     2              RO,        THETAO,   PHIO,     PLUS,     NPOWFR,    INPU0005
     3              NPLOT,     J,        NUAR,     N1,       FN,        INPU0006
     4              DNDR,      DNDI,     DNDP,     EMU,      RIYSQR,    INPU0007
     5              F,         F2,       C1,       FH,       COSPSI,    INPU0008
     6              SINPSI,    DFHDR,    DFHDT,    DCPDT,    DCPDY1,    INPU0009
     7              DCPDY2,    DCPDY3,   SP2,      FMUINT,   EMUS,      INPU0010
     8              N,         GNU,      MUFLAG                         INPU0011
      COMMON  /HBANK1/ MORDER,     NOHALF,   MODOUR,   HBANK,   NOEQ,   INPU0012
     1                 FINVP,      FINVPI,   YO(11),   YD(11),  MA(260)INPU0013
      COMMON /CRSR/ C,RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,YO6           INPU0017
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLOW,HMAXI,HMINI,KD           INPU0018
      COMMON /NEW/ PLOTU,RDOT
       COMMON/RECT/UD(3002),SOA(3002), LR
      COMMON /RSN/ IRSN
      COMMON / RBLK1  /  SIZM5 , HPRIME , PKDELN , AMBDL , HO
C
C
      COMMON /GRAPH0/  XMAXO ,XMINO ,YMAXO ,YMINO , PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /GRAPH2/  TITLE
C
C
      DIMENSION  V(3) ,W(3)
      DATA  V / 0.9788 , 0.0196 , 0.0016 /
      DATA  W / 66.546 , 265.98 , 1056.3 /
C
      DIMENSION TITLE(20)
      DIMENSION PLT(15) , DATE(4)
      DIMENSION D( 30)
C
      NAMELIST / XNAME5 /  XMAXO , XMINO , YMAXO , YMINO ,
     1                     XMAX1 , XMIN1 , YMAX1 , YMIN1
      NAMELIST / XNAME3 /  ORDER , EUBAR , ELBAR ,
     1                     YCLOW , HMAXI , HMINI , KD
      NAMELIST / XNAME1 /      D ,  LAST ,NTITLE ,NCONST , LIMITS
C
C     FORMAT STATEMENTS
C
  781 FORMAT(8F10.3)
  981 FORMAT(10X,8F10.4)
  500 FORMAT(20A4)
  501 FORMAT(40I2)
  999 FORMAT(  1H1 , 20X , 20A4 )
 1000 FORMAT(  // 20X , 30HINITIAL RAY POSITION           ,
     1            10X , 30HINITIAL RAY DIRECTION          ,
     2         // 20X ,  7HRO      , F10.2 , 23X , 7HAO      , F6.2 ,
     3          / 20X ,  7HTHETAO  , F10.2 , 23X , 7HRO      , F6.2 ,
     4          / 20X ,  7HPHIO    , F10.2 , 23X , 7HDELAO   , F6.2   )
 1001 FORMAT(  // 20X , 30HRAY CHARACTERISTICS            ,
     1            10X , 30HFIELD LINE                     ,
     2         // 20X ,  7HFREQ    , F5.2 ,  27X , 7HLAMBDA  , F7.2 ,
     3          / 20X ,  7HMODE    ,  I2  ,  30X , 7HL-VALUE , F7.2   )
```

```
1002 FORMAT( // 30X , 30HSTOP CONDITIONS                     ,
     1                 30HINTERVALS                          ,
     2          / 30X , 15H MAX          MIN      ,
     3          / 20X ,  7HRADIUS   , 2F9.1 , 15X ,  7HPRINT   , F6.1 ,
     4          / 20X ,  7HTHETA    , 2F9.1 , 15X ,  7HPLOT    , F6.1 ,
     5          / 20X ,  7HPHI      , 2F9.1 , 15X ,  7HSTEP    , F6.1   )
1003 FORMAT( // 20X , 30HPROGRAM OPTIONS                     ,
     1            10X , 30HOTHER INITIAL VALUES               ,
     2         // 20X ,  7HNPOWER  , I1 , 32X , 12HSCALE SIZE   , F7.3 ,
     3          / 20X ,  7HNPLOT   , I1 , 32X , 12HPKFRAC       , F7.3 ,
     4          / 20X ,  7HNOVER   , I1 , 32X , 12HHPRIME       , F7.3 ,
     5          / 20X ,  7HNAUTO   , I1 , 32X , 12HPKDELN       , F7.3 ,
     6          / 20X ,  7HJTEST   , I1         )
C                                                           INPU0025
      RAD=.01745329
      RPERD = 0.01745329
      RDOT = 0.
      REARTH = 6378.0
C                                                           INPU0021
      IF( LAST .GT. 0 ) GO TO 11
      READ( 5,XNAME1 )                                                4
      IF( NTITLE .GT. 0 ) READ( 5,500 ) TITLE                         6
      IF( NCONST .GT. 0 ) READ( 5,XNAME3 )                            9
      IF( LIMITS .GT. 0 ) READ( 5,XNAME5 )
C
C
C                                                                    11
      RO      =  D(01)
      THETAO  =  D(02)
      PHIO    =  D(03)
      AO      =  D(04)
      BO      =  D(05)
      DELAO   =  D(06)
C
C     LOAD MAX AND MIN VALUES OF R, THETA AND PHI
C
      RMAX  =  D(07)
      RMIN  =  D(08)
      TMAX  =  D(09) * RPERD
      TMIN  =  D(10) * RPERD
      PMAX  =  D(11) * RPERD
      PMIN  =  D(12) * RPERD
C
      PRINT  =  D(13)
      PRNT   =  PRINT
      PLINT  =  D(14)
      PLOTO   = PLINT
      HBANK  =  D(15)
C
      F     = D(16)
      MODE  = D(17)
      PLUS   = MODF
      JTEST  = D(18)
      J      = JTEST
C
      NPOWER = D(19)
```

```
      NPLOT  = D(20)
      NOVER  = D(21)
      NAUTO  = D(22)
C
      HO     = D(23)
      PKFRAC = D(24)
      AMBDL  = D(25)
C
C     CALCULATE  RO
C
      AMBDA  = AMBDL * RPERD
      THO    = THETAO * RPERD
C
      SNLAM1 = SIN( AMBDA )                                         21
      SNLAM2 = SNLAM1 * SNLAM1
      SNLAM3 = SNLAM2 * SNLAM1
C
      SNTHO1 = SIN( THO )                                           22
      SNTHO2 = SNTHO1 * SNTHO1
      SNTHO3 = SNTHO2 * SNTHO1
C
      TNTHO1 = TAN( THO )                                           23
      TNTHO2 = TNTHO1 * TNTHO1
C
      STSL   =  SNTHO1 / SNLAM1
      ZM1 =  SQRT ( 4.0 - 3.0 * SNTHO2 )                            24
      ZM2 =  SQRT ( 4.0 - 3.0 * SNLAM2 )                            25
      ZM3 =  ZM2 * SNTHO3
      ZM4 =  ZM1 * SNLAM3
      ZM5 =  ZM3 / ZM4
C
      H = HO * ZM5
      HPRIME =  .707 * H
      HPRIM1 =  SQRT ( 1.0 + 4.0/  TNTHO2 )
C                                                                   26
      STZM5  = ZM5
      IF( NAUTO .LE. 0 ) GO TO 60
      RO  =  REARTH * STSL * STSL  -  HPRIME * HPRIM1
      D(01) = RO
   60 CONTINUE
C
C
C     CALCULATE  AO
C
      WALSH1  =  0.5 * TAN( THO )                                   31
      WALSH2  =  ATAN( WALSH1 )                                     32
      WALSH3  =  WALSH2 / RPERD
      AO      =  WALSH3 + DELAO
      D(04)   =  AO
C
C     CALCULATE ELECTRON DENSITY AT RO,THETAO,PHIO
C
      W1  = ( RO - 6728. ) / 50.
      T17 = 0.5 * ( 1.0 - W1 - EXP(-W1) )                           33
      ENF = 2.7E5 * EXP( T17 )                                      34
      ZX  = 6878.0 *( 1. - 6878./ RO )
```

```
C
C
      ENXR   = 0.0
      DO 100 I = 1,5
  100 ENXR = ENXR + V(I) * EXP( -ZX / W(I) )                    40
      FNXR =          SQRT( ENXR )                              44
      ENXR  =  4.0 * ENXR
C
C
      ENX  = ENXR * ( 1.659E3 * ABS( THO - 1.5707963 ) + 16620. )
      IF( RO - 7378. ) 40,41,41
   40 TM  =(RO - 7378.)/ 500.
      FACTOR  = EXP( - TM*TM )                                  47
      ENX  = ENX * FACTOR
   41 EN = ENX + ENF
      PKDELN = PKFRAC * EN
C
C     LOAD PLOTTING TITLE INFORMATION
C
      PLT(01)  =  RO
      PLT(02)  =  THETAO
      PLT(03)  =  PHIO
      PLT(04)  =  AO
      PLT(05)  =  BO
      PLT(06)  =  DELAO
      PLT(07)  =  AMBDL
      PLT(08)  =  PKFRAC
      PLT(09)  =  HPRIME
      PLT(10)  =  HO
      PLT(11)  =  H1
      PLT(12)  =  F
      PLT(13)  =  MODE
C
C
C
C
      A  =  AO * RPERD
      B  =  BO * RPERD
C
      YO(01)  =  RO
      YO(02)  =  THETAO * RPERD
      YO(03)  =  PHIO   * RPERD
      YO(04)  =  COS(A)                                         49
      YO(06)  =  SIN(A) * SIN(B)                                50    51
      YO(05)  =  SIN(A) * COS(B)
C                                                               52    53
      F2 =        F * F
      C1 =  1.24E4 * F2
C
  112 CALL DENSE                                        INPU0084
C                                                               55
      X    = EN / C1
      TERM = 1. - X
C
C     TEST IF VALUE OF TERM IS ABNORMAL
C
```

```
      IF( TERM ) 2000,2000,2001
 2000 IRSN = 1
      WRITE(6,2002) TERM                                         59
 2002 FORMAT( 14H INPUT TERM = ,F15.5)
      RETURN
 2001 CONTINUE
C
      TERM2 = TERM * TERM
      C     = COS( RHO )                                         61
      S     = SIN( RHO )
C                                                                62
      Y042 = YO(4) * YO(4)
      Y052 = YO(5) * YO(5)
      Y062 = YO(6) * YO(6)
      YSQUAR= Y042 + Y052 + Y062
      RTYSQR  = SQRT( YSQUAR )
C                                                                63
  115 CALL FIELD                                   INPU0091
C                                                                65
      Y       =  FM / F
      YT      =   Y * SINPSI
      YT2     =  YT * YT
      YL      =   Y * COSPSI
      YL2     =  YL * YL
      YLYT    =  YL * YT
      EM      =  0.5 * YT2 / TERM
      EMRAD =  PLUS * SQRT( EM* EM + YL2 )                       67
      FMD   =  1. - EM + EMRAD
      EMUS  =  1. -  X / EMD
C
C     TEST IF VALUE OF EMUS IS ABNORMAL
C
      IF( EMUS ) 2003,2003,2004
 2003 IRSN = 1
      WRITE(6,2005) EMUS                                         70
 2005 FORMAT( 14H INPUT EMUS = , E15.5)
      RETURN
 2004 CONTINUE
      EMUZ  =  SQRT( EMUS)                                       72
      EMUINT  =  EMUZ
C
C
      YO(04)  =  YO(04) * EMUZ
      YO(05)  =  YO(05) * EMUZ
      YO(06)  =  YO(06) * EMUZ
      YO(07)  =  0.0
      YO(08)  =  0.0
      YO(09)  =  1.0
      YO(10)  =  0.0
      YO(11)  =  0.0
      NVAR    =  10
C
C
C     TEST PROGRAM OPTION INDICATORS
C
      IF( NPLOT .LE. 0 ) GO TO 9
```

```
      IF( NOVER ) 62,62,63
   62 CALL CALCO1                                                         79
      GO TO 9
   63 CALL CALCO3
                                                          MAIN0027        82
    9 CONTINUE
      EL      = 1.0 / SNLAM2

      WRITE(6, 999)   TITLE                                               84
      WRITE(6,1000)   RO , AO , THETAO , BO , PHIO , DELAO                86
      WRITE(6,1001)       F,  AMBDL,   MODE,      EL                      87
      WRITE(6,1002)   D(7) , D(8) , D(13) ,
     1                D(9) , D(10), D(14) ,
     2                D(11), D(12), D(15)                                 88
      WRITE(6,1003)   NPOWER,      HO,  NPLOT, PKFRAC,
     1                 NOVER, HPRIME,  NAUTO, PKOFLN, JTEST               89
      RETURN                                              INPU0117
C
   11 IF( NPLOT .GT. 0 )  CALL CALCO2                                     92
      STOP
      END
```

```
$IBFTC OUTPU   LIST,REF
```

```
      SUBROUTINE OUTPUT(IFLAG)                                          OUTP0002
      COMMON/EPSTN/EPST1, PROPT                                         OUTP0006
      COMMON /DATA/ RMAX,      PMIN,      TMAX,      TMIN,      PMAX,   OUTP0007
     1               PMIN,      PRNT,      RELEPR,    AO,        RO,     OUTP0008
     2               RO,        THETAO,    PHIO,      PLUS,      NPOWER, OUTP0009
     3               NPLOT,     J,         NUAR,      N1,        FN,     OUTP0010
     4               DNDR,      DNDT,      DNDP,      EMU,       DTYSOR, OUTP0011
     5               F,         F2,        C1,        FH,        COSPSI, OUTP0012
     6               SINPSI,    DFHDR,     DFHDT,     DCPDT,     DCPDY1, OUTP0013
     7               DCPDY2,    DCPDY3,    SP2,       FMUINI,    FMUS,   OUTP0014
     8               N,         GNU,       MUFLAG                        OUTP0015
      COMMON  /HBANK1/ MORDER,     NCHALF,     HODOUB,     HBANK,     NOEO, OUTP0016
     1                 FINVP,      FINVPI,     YO(11),     YD(11),    MA(260)OUTP0017
      COMMON /CHSR/ C,RCT,S,RST,Z,FM,ERM,TER2,RMOD,RARG,YO6             OUTP0018
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,F1T,DNMNTR,DEL2S            OUTP0019
      COMMON /POWLOS/  COSA,       Y,        DMD,       DMDT,      DMDP,  OUTP0020
     1                 DMFY1,      DMDY2,    DMDY3,     DMDSI,     DMDDSI, OUTP0021
     2                 DMUDR,      DMUDT,    DMUDP,     DMUDY1,    DMUDY2, OUTP0022
     3                 DMUDY3,     DMUDSI,   EMU,       FMRAD              OUTP0023
C
C
       DIMENSION XX(502),YY(502)
      DIMENSION  DATE(04) ,   PLT(15)
      DIMENSION TITLE(20)
C
      COMMON /GRAPH2/  TITLE
      COMMON / RECT  /    DD  ,  SOA  , LB
      COMMON / RDUTS /   JUMP  , NYD1
C
C
      THETA=57.2957795*YO(2)                                            OUTP0024
      PHI=57.2957795*YO(3)                                              OUTP0025
C
  200 DSHIFT=-2.424067E-6*F*YO(10)                                      OUTP0026
  201 VALCRT=SQRT(DMUDR*DMUDR+(DMUDT/YO(1))**2+(DMUDP/RCT)**2)          OUTP0027
     1      /(20.943933*F*EMUS)                                         OUTP0028
C
      IF(JUMP .EQ. 2 ) GO TO 101
  202 JUMP = 1                                                          OUTP0029
  203 IF (JFLAG .NE. 10 ) GO TO 100                                     OUTP0030
  204 IF(N .EQ. 0) RETURN
C
  101 LL=LL+1                                                           OUTP0032
      XX(LL)=YO(1)                                                      OUTP0033
      YY(LL)=THETA                                                      OUTP0034
  206 IF (LL .EQ. 500) GO TO 46                                         OUTP0037
      GO TO (29,46) , JUMP                                              OUTP0038
  100 IF(N.NE.0) GO TO 27                                               OUTP0040
C
  207 C2=4.2473703E-6/F                                                 OUTP0041
      LL=1                                                              OUTP0042
      XX(1)=RO                                                          OUTP0043
      YY(1)=THETAO                                                      OUTP0044
      GO TO 209
C
```

```
  26 IF(N.NE.13) GO TO 27                                       OUTP0047
 209 WRITE(6,1007) TITLE                                                    32
  28 WRITE(6,1002)                                              OUTP0049    34
 210 N = 1                                                      OUTP0050
  27 YOSQR = YO(4)**2 + YO(5)**2 + YO(6)**2                     OUTP0052
C                                                               OUTP0053
C     GROUP DELAY IN MILLISECONDS                               OUTP0054
C                                                               OUTP0055
 211 GRODEL=YO(7)/3.0E2                                         OUTP0056
C
 212 CALL POLAR                                                 OUTP0057    39
     RARG = RARG*57.2957795                                     OUTP0058
C
 213 IF(NPOWER.NE.0) GO TO 21                                   OUTP0059
 214 PL=0.0                                                     OUTP0060
     DEL2S=0.0
     GO TO 22                                                   OUTP0062
  21 PL=10.*ALOG10(EMU*PROPT*EXP(-YO(11)))                      OUTP0063
C
C                                                                           47    48
  22 WRITE(6,1003) FINVD,YO(1),THETA,PHI,YO(3),DSHIFT,PL,       OUTP0064
    1             YO(2),YO(4),YO(5),YO(6),EPHIS,YOSQR,EPSTIN,   OUTP0065
    2             YO(8),RMOD,RARG,VALCRT,EN,GNU,GRODEL          OUTP0066    49
 215 N = N + 1                                                  OUTP0067
C
C
 216 GO TO (29,40,41,42,43,44,45,29,47,29,29 ) , JFLAG          OUTP0068
C
  40 WRITE(6,2040)                                              OUTP0069    52
     GO TO 217                                                  OUTP0071
  41 WRITE(6,2041)                                              OUTP0072    54
     GO TO 217                                                  OUTP0074
  42 WRITE(6,2042)                                              OUTP0075    56
     GO TO 217                                                  OUTP0077
  43 WRITE(6,2043)                                              OUTP0078    58
     GO TO 217                                                  OUTP0080
  44 WRITE(6,2044)                                              OUTP0081    60
     GO TO 217
  45 WRITE(6,2045)                                              OUTP0087    62
 217 JUMP = 2                                                   OUTP0082
     GO TO 101                                                  OUTP0083
C
  47 WRITE (6,2046) YD(1)                                       OUTP0085    65
     IF (ABS(THETA - 90. ) .LT. 2.0 ) GO TO 101
     NYD1 = NYD1 + 1
     GO TO 101

  46 IF( NPLOT .EQ. 0 ) RETURN
     CALL CALC04( LB , ND , SOA )                                           73
     CALL CALC05( LL , YX , YY  )

     RESET COUNTERS

     JUMP =  1                                                              75
     LL   =  0
     LB   =  0
```

```
C
   29 RETURN
C
C     FORMAT STATEMENTS
C
 2040 FORMAT(25HOSTOPPED ON TEST FOR RMAX)                              OUTP0098
 2041 FORMAT(25HOSTOPPED ON TEST FOR RMIN)                              OUTP0099
 2042 FORMAT(30HOSTOPPED ON TEST FOR THETA MAX)                         OUTP0100
 2043 FORMAT(30HOSTOPPED ON TEST FOR THETA MIN)                         OUTP0101
 2044 FORMAT(28HOSTOPPED ON TEST FOR PHI MAX)                           OUTP0102
 2045 FORMAT(28HOSTOPPED ON TEST FOR PHI MIN)                           OUTP0103
 2046 FORMAT (9HORDOT =   E15.6 )                                       OUTP0104
 1002 FORMAT(10X10HPHASE PATH6X6HRADIUS10X10HCOLATITUDE6X9HLONGITUDE7X10OUTP0105
     1HABSORPTION6X10HDOPPLER SP6X10HPOWER LOSS/10X10HGROUP PATH6X2HY114OUTP0106
     2X2HY214X2HY314X5HMU**211X4HY**212X10HEPSTEIN CD/10X8HRAY PATH8X26HOUTP0107
     3POLARIZATION - MOD AND ARG6X6HDEL MU10X1HN15X2HNU14X              OUTP0108
     411HGROUP DELAY)                                                   OUTP0109
 1003 FORMAT(/6X1P7E16.7/(6X7E16.7))                                    OUTP0110
 1007 FORMAT( 1H1 , 20X , 20A4 )
      END                                                               OUTP0112
```

$IBFTC SC

```
      BLOCK DATA
      COMMON /GRAPH0/  XMAX0 ,XMIN0 ,YMAX0 ,YMIN0 , PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
      COMMON /CONST / ORDER, EUBAR,ELBAR,YCLOW,HMAXI,HMINT,KD              MAIN0016
C
C     NOMINAL PLOT LIMITS
C
      DATA  YMIN0 , YMAX0  / 0.0E0 , 1.2E4 /
      DATA  XMIN0 , XMAX0  /-1.8E1 , 2.0E0 /
      DATA  XMIN1 , XMAX1  / 0.0E0 , 2.0E4 /
      DATA  YMIN1 , YMAX1  / 0.0E0 , 1.0E4 /
C
C     NOMINAL INTEGRATION PARAMETERS
C
      DATA  ORDER , EUBAR , ELBAR / 1.0E 0 , 1.0E-5 , 1.0E-7 /
      DATA  YCLOW , HMAXT , HMINT / 1.0E-7 , 1.0E 4 , 1.0E-7 /
C
      END
```

SIBFIC SCA

```
      SUBROUTINE  PRAM(X,Y,LL,XMIN,YMIN,XMAX,YMAX,XLEN,YLEN)
      DIMENSION X(1),Y(1)
C
     X( LL + 1 ) = XMIN
     Y( LL + 1 ) = YMIN
C
     X( LL + 2 ) = ( XMAX - XMIN ) / XLEN
     Y( LL + 2 ) = ( YMAX - YMIN ) / YLEN
     RETURN
     END
```

SIBFIC CALCO

```
      SUBROUTINE CALCO4(LL,X,Y)
C
      COMMON /GRAPH0/  XMAX0 ,XMIN0 ,YMAX0 ,YMIN0,PLT
      COMMON /GRAPH1/  XMAX1 ,XMIN1 ,YMAX1 ,YMIN1,DATE
C
      DIMENSION PLDAT(360) ,  X(3002) , Y(3002)
      DIMENSION    PLT(15) ,  DATE(5)
C
      MODE = PLT(13)
C
      CALL  PRAM(X,Y,LL,XMIN0,YMIN0,XMAX0,YMAX0,10.,12.)                    3
C
      IF( LVAL .NE. 1 ) GO TO 12
      CALL AXIS(0.0,0.0,21HDIS FROM FLD LN IN KM,21,10.,90.0, X(LL+1),
     1 X(LL+2))                                                             10
      CALL AXIS(0.0,0.0,24HDIS ALONG FLD LN IN KM          ,-24,12.0,
     10.0, Y(LL+1), Y(LL+2))
C                                                                           14
      CALL SYMBOL (1.0,9.6,0.10,8HRO     = ,0.0,8)                          16
      CALL NUMBER (2.0,9.6,0.1, PLT(01) , 0.0 , 2 )                         18
      CALL SYMBOL (4.0,9.6,0.10,8HAO      =,0.0,8)                          20
      CALL NUMBER (5.0,9.6,0.1, PLT(04) , 0.0 , 3 )                         22
      CALL SYMBOL (7.0,9.6,0.10,8HDELAO   =,0.0,8)                          24
      CALL NUMBER (8.0,9.6,0.1, PLT(06) , 0.0 , 3 )                         26
      CALL SYMBOL (1.0,9.2,0.10,8HTHETA   =,0.0,8)                          28
      CALL NUMBER (2.0,9.2,0.1, PLT(02) , 0.0 , 3 )                         30
      CALL SYMBOL (4.0,9.2,0.10,8HRO      =,0.0,8)                          32
      CALL NUMBER (5.0,9.2,0.1, PLT(05) , 0.0 , 2 )                         34
      CALL SYMBOL (7.0,9.2,0.10,8HHPRIME =,0.0,8)                           36
      CALL NUMBER (8.0,9.2,0.1, PLT(09) , 0.0 , 3 )                         38
      CALL SYMBOL (1.0,8.8,0.10,8HPHI     =,0.0,8)                          40
      CALL NUMBER (2.0,8.8,0.1, PLT(03) , 0.0 , 3 )                         42
      CALL SYMBOL (4.0,8.8,0.10,8HPKFRAC =,0.0,8)                           44
      CALL NUMBER (5.0,8.8,0.1, PLT(08) , 0.0 , 3 )                         46
      CALL SYMBOL (1.0,8.4,0.10,8HLAMBDA =,0.0,8)                           48
      CALL NUMBER (2.0,8.4,0.1, PLT(07) , 0.0 , 3 )                         50
      CALL SYMBOL (4.0,8.4,0.10,8HHO      =,0.0,8)                          52
      CALL NUMBER (5.0,8.4,0.1, PLT(10) , 0.0 , 3 )                         54
      CALL SYMBOL (1.0,8.0,0.10,8HFREQ    =,0.0,8)                          56
      CALL NUMBER (2.0,8.0,0.1, PLT(12) , 0.0 , 3 )                         58
      CALL SYMBOL (4.0,8.0,0.10,8HH1      =,0.0,8)                          60
      CALL NUMBER (5.0,8.0,0.1, PLT(11) , 0.0 , 3 )
C                                                                           62
      IF(MODE) 10,12,11
   10 CALL SYMBOL (7.0,8.8,0.1,18HEXTRAORDINARY MODE,0.0,18)                66
      GO TO 12
   11 CALL SYMBOL (7.0,8.8,0.1,13HORDINARY MODE,0.0,13)                     69
   12 CALL LINE(Y,X,LL,KVAL,JVAL,LVAL)                                      71
      RETURN
C
       ENTRY CALCO5(LL,X,Y)
C
      CALL PLOT(17.5,5.,-3)                                                 74
       DO 600 II=1,LL
       AR=X(II)
```

```
      Y(II)=Y(II)*3.14159/180.
      X(II)=AR*SIN(Y(II))                                            83
  600 Y(II)=AR*COS(Y(II))
C                                                                    87
      CALL PRAM(X,Y,LL,XMIN1,YMIN1,XMAX1,YMAX1,10.,5.)               91
      CALL LINE(X,Y,LL,KVAL,JVAL,LVAL)
C                                                                    93
      IF(LVAL.NE.1) RETURN
     CALL AXIS(0.,0.,1H ,-1,10.,0.,0.,  X(LL+2) )                    98
     CALL AXIS(0.,0.,1H , 1, 4.,90.,0.,  Y(LL+2) )
C                                                                    101
      IC=201
      PHI=0.
      DO 300 I=1,IC
      X(I)=6378.*SIN(PHI)                                            107
      Y(I)=6378.*COS(PHI)                                            109
  300 PHI=PHI+.03141796
C
      CALL PRAM(X,Y,IC,XMIN1,YMIN1,XMAX1,YMAX1,10.,5.)               114
      CALL LINE(X,Y,IC,1,0,0)                                        116
      RETURN
C
     ENTRY CALCO1
C
     LVAL = 1
     KVAL = 1
     JVAL = 0
     CALL PLOTS(PLDAT(1),360 )                                       122
      CALL PLOT(0.,-11.,0,-3)                                        124
      CALL PLOT(20.,0.5,-3)                                          126
     RETURN
C
     ENTRY CALCO2
C
     CALL PLOT(15.,0.,-3)                                            129
     CALL PLOT(0,0,999)                                              131
     RETURN
C
     ENTRY CALCO3
C
C
     CALL PLOT ( -17.5 , -5.0 , -3)                                  134
     LVAL = LVAL + 1
     RETURN
     END
```

$IBFTC DENS

```
      SUBROUTINE DENSE                                                DENS0004
      DIMENSION  DD(3002) , SDA(3002)
      COMMON / RECT  /      DD ,  SOA , LB
C                                                                     DENS0010
      COMMON /DATA/ RMAX(19),     EN,     DNDR,     DNDI,     DNDP,   DENS0011
     1                EMU(21)                                         DENS0012
C                                                                     DENS0013
      COMMON /HBANK1/ MORDER(7),   YO(11),   YD(11),   SCR(260)       DENS0014
      COMMON / RBLK1  /   STZM5 , HPRIME , PKDELN , AMBDL , H0
C                                                                     DENS0015
C                                                                     DENS0015
      RPERD = 0.01745329
      RAD = 6378.
      DISMAX  =  2.0
      R = YO(1)
      TH      = YO(2)
C
      AMBDA   = AMBDL  * RPERD
C
      SNLAM1 = SIN( AMBDA )                                           2
      SNLAM2 = SNLAM1 * SNLAM1
      SNLAM3 = SNLAM2 * SNLAM1
C
      SNTH1   = SIN( TH )                                             3
      SNTH2   = SNTH1 * SNTH1
      SNTH3   = SNTH2 * SNTH1
C
      CSTH1   = COS( TH )
C                                                                     4
      TNTH1   = TAN( TH )                                             5
      TNTH2   = TNTH1 * TNTH1
C
      STSL    = SNTH1 / SNLAM1
C
      ZM1 = SQRT ( 4.0 - 3.0 * SNTH2  )                               6
      ZM2 = SQRT ( 4.0 - 3.0 * SNLAM2 )                               7
      ZM3 = ZM2 * SNTH3
      ZM4 = ZM1 * SNLAM3
      ZM5 = ZM3 / ZM4
C
      H = H0 * ZM5
      DIFF    =  1.0 - (RAD / R) * STSL * STSL
      TWO =  2.0 / TNTH1
      DTHETA =  DIFF * TWO / ( 1.0 + TWO * TWO )
      THETA1 = TH + DTHETA
C
      TNTH11 =  2.0 / TAN(THETA1)                                     8
      DIS  =  R * DIFF / SQRT( 1.0 + TNTH11 * TNTH11 )
C
C
C
C
C     CALCULATE  ELECTRON DENSITY OF F-REGION -ENF-
C                                                                     9
      W1     = (R - 6728.) / 50.0
```

```
      T17    = 0.5 * ( 1.0 - W1 - EXP(-W1) )                     10
      ENF    = 2.7E5 * EXP(T17)
C     -                                                          11
      DENFDR = -0.01 * ( 1.0 - EXP(-W1) ) * ENF
C
C     CALCULATE  ELECTRON DENSITY OF EXOSPHERE -ENX-
C                                                                12
      ZX     = 6878.0 * ( 1.0 - 6878./R )
      DZXDR = (6878./YO(1))**2
      ENXR = SQRT(.9788*EXP(-ZX/66.546)+.0196*EXP(-ZX/265.98)+.0016*EXP(
     1 -ZX/1056.3))                                              13   14   15   16
      ENXR  =   4.0 * ENXR
      ENX  = ENXR * ( 1.659E 3 * ABS( TH - 1.5707963 ) + 16620. )
      DENXDR = -.5*ENX/ENXR**2*DZXDR*(.9788/66.546*EXP(-ZX/66.546)+.0196
     1 /265.98*EXP(-ZX/265.98)+.0016/1056.3*EXP(-ZX/1056.3))     17   18   19
      DENXDT =  1.659E 3 * ENXR / RPERD
      IF(YO(1)-7378.) 40,41,41
   40 FACTOR = EXP(-((YO(1)-7378.)/500.)**2 )                    22
      ENX = ENX * FACTOR
      DENXDR = DENXDR*FACTOR - ENX*2.*(YO(1)-7378.)/500.**2
      DENXDT = DENXDT * FACTOR
   41 EN = ENX + ENF
C
C     CALCULATE  DERIVATIVES OF ELECTRON DENSITY
C
      PKFRAC = PKDELN/EN*(SIZM5/ZM5)
      FRACIN = PKFRAC * EXP(-(DIS/H)**2)
C
C                                                                24
      DFDN = -2.*DIS/H**2 * FRACIN
      T31 = EN/(1.+FRACIN)*DFDN/(1.+4./TAN(THETA1)**2)           25
      DNDR = DENFDR + DENXDR + T31
      CYO2 = COS(YO(2))                                          26
      DNDT = -CYO2/ABS(CYO2)*(DENXDT +EN/(1.+FRACIN)*DFDN/(1.+.25*TAN(
     1 THETA1)**2)*YO(1))                                        27
  118 DNDP=       0.
      AY2 = YO(2)*57.29
    3 FORMAT ( 1H  ,4PE12.1,2PE12.3,1P8E11.3 )
C
C
      IF( DIS .GT. DISMAX ) GO TO 12
      IF( LB  .GT. 2998   ) GO TO 12
C
      LB = LB + 1
      DD(LB) = DIS
      COAM = COS(AMBDA)                                          37
      SIAMS = SIN( AMBDA )**2                                    38
      SL = SQRT(1.33333-SIAMS)                                   39
      SI = SQRT(1.33333-SIN(YO(2))**2 )                          40   41
      SOA(LB) =.8660254/SIAMS*(COAM*SL-COS(YO(2) )*SI+ ALOG( (COAM+SL)/
     1  ( COS(YO(2) ) + SI ) )/3.  )*RAD
C
C                                                                42   43   44
   12 CONTINUE
      RETURN                                          DENS0086
      END                                             DENS0087
```

```
$IBFTC EILL
```

```
      SUBROUTINE FIELD                                                  FIEL0002
      COMMON/EXFLD/D2CY1R,D2SY1R,D2CY2T,D2SY2T,D2CY3P,D2SY3P            FIEL0003
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       FIEL0004
     1              PMIN,     PRNT,     RELERR,   AO,       RO,         FIEL0005
     2              RO,       THETAO,   PHIO,     PLUS,     NPOWER,     FIEL0006
     3              NPLOT,    J,        NOAR,     N1,       EN,         FIEL0007
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,     FIEL0008
     5              F,        F2,       C1,       FH,       COSPSI,     FIEL0009
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,     FIEL0010
     7              DCPDY2,   DCPDY3,   SP2,      FMUINT,   FMUS,       FIEL0011
     8              N,        GNU,      MUFLAG,   NTFST                 FIEL0012
      COMMON /HBANK1/ MORDER,   NOHALF,   NODOUB,   HBANK,    NOEQ,     FIEL0013
     1              FINVP,    FINVPI,   YO(11),   YD(11),   MA(260)FIEL0014
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,F1T,DNMNTR,DEL2S            FIEL0015
      COMMON /CKSR/ C,RCT,S,RST,Z,FM,TERM,TERM2,RMOD,RARG,YO6           FIEL0016
  100 F1T=1.+3.*C**2                                                    FIEL0017
      F2T=3.*S/F1T*C                                                    FIEL0018
  101 RTF1T=SQRT(F1T)                                                   FIEL0019   3
  102 FH=(6157.891/YO(1))**3*RTF1T                                      FIEL0020
  103 DFHDR=-3.*FH/YO(1)                                                FIEL0021
      DFHDT=-F2T*FH                                                     FIEL0022
  104 DFHDP=0.                                                          FIEL0023
  105 DNMNTR=RTYSQR*RTF1T                                               FIEL0024
  106 COSPSI=(2.*YO(4)*C+YO(5)*S)/DNMNTR                                FIEL0025
  107 SP2=1.-COSPSI**2                                                  FIEL0026
      IF (SP2 .LE. 0.0 )  SP2 = 0.0
      YO4S = S* YO(4)                                                   FIEL0027
      YO5C = C* YO(5)                                                   FIEL0028
      SINPSI = SIGN (SQRT (SP2),(YO5C*2. - YO4S))                       FIEL0029   12
      DCPDR=0.                                                          FIEL0030
      DCPDT = F2T * COSPSI + (YO5C - YO4S*2.)/ DNMNTR                   FIEL0031
      DCPDP=0.                                                          FIEL0032
      F1P=COSPSI/YSQUAR                                                 FIEL0033
      DCPDY1=2.*C/DNMNTR-YO(4)*F1P                                      FIEL0034
      DCPDY2=S/DNMNTR-YO(5)*F1P                                         FIEL0035
      DCPDY3=-YO(6)*F1P                                                 FIEL0036
      D2CY2T=-YO(5)*DCPDT/YSQUAR+4./DNMNTR*C/F1T                        FIEL0037
  108 D2SY2T=-(COSPSI*D2CY2T+DCPDT*DCPDY2/SINPSI**2)/SINPSI             FIEL0038
      RETURN                                                            FIEL0039
      END                                                               FIEL0040
```

$IBFTC POWER

```
C                                                                  POWE0002
C     SUBROUTINE TO COMPUTE POWER LOSS                             POWE0004
      SUBROUTINE POWERL                                            POWE0005
      DIMENSION A(3,3),B(3,3)                                      POWE0006
      DIMENSION  YP(11)                                            POWE0007
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,  POWE0008
     1              PMIN,     PRNT,     RELERR,   AO,       BO,    POWE0009
     2              RO,       THETAO,   PHIO,     PLUS,     NPOWER,POWE0010
     3              NPLOT,    J,        NUAR,     N1,       FN,    POWE0011
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,POWE0012
     5              F,        F2,       C1,       FH,       COSPSI,POWE0013
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,POWE0014
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   FMUS,  POWE0015
     8              N,        GNU,      MUFLAG                     POWE0016
      COMMON  /HBANK1/ MORDER,     NOHALF,   NODOUB,   HBANK,    NOEQ,   POWE0017
     1                 FINVP,      FINVPI,   YO(11),   YD(11),   MA(260)POWE0018
      COMMON /POWLOS/  COSA,       Y,        DMDR,     DMDT,     DMDP,   POWE0019
     1                 DMDY1,      DMDY2,    DMDY3,    DMDSI,    DMDDSI, POWE0020
     2                 DMUDR,      DMUDT,    DMUDP,    DMUDY1,   DMUDY2, POWE0021
     3                 DMUDY3,     DMUDSI,   EMU,      EMRAD           POWE0022
      COMMON /CRSR/ C,RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,YO6      POWE0023
      COMMON/GAUSS/YSQUAR,DCPDR,DCPDP,DFHDP,FIT,DNMNTR,DEL2S       POWE0024
      COMMON/EXFLD/D2CY1P,D2SY1R,D2CY2T,D2SY2T,D2CY3P,D2SY3P       POWE0025
      EQUIVALENCE(YP(1),YO(1))                                     POWE0026
C                                                                  POWE0027
C     COMPUTE MISCELLANEOUS VARIABLES                              POWE0028
C                                                                  POWE0029
  500 Y2=Y**2                                                      POWE0030
      TERMC1 = TERM*C1                                             POWE0031
      COSPS2 = COSPSI**2                                           POWE0032
      AA2 = EMD**2                                                 POWE0033
      YC = Y2*COSPSI                                               POWE0034
      AA2C1 = AA2*C1                                               POWE0035
      ENDA2C = EN/AA2C1                                            POWE0036
      XTERM=ENDA2C/(2.*EMU)                                        POWE0037
      EMRAD2=EMRAD**2                                              POWE0038
      FHCSP2=2.*FH*COSPSI                                          POWE0039
  501 F2C=FH/F2*COSPS2                                             POWE0040
  502 IF(MUFLAG)79,80,79                                           POWE0041
   80 TO=THETAO/57.2957795                                         POWE0042
      PO=PHIO/57.2957795                                           POWE0043
      SIPO=SIN(PO)                                                 POWE0044   6
      COPO=COS(PO)                                                 POWE0045   7
      SITO=SIN(TO)                                                 POWE0046   8
      COTO=COS(TO)                                                 POWE0047   9
      RO2=RO**2                                                    POWE0048
  503 MUFLAG = 1                                                   POWE0049
   79 COP=COS(YP(3))                                               POWE0050  12
      SIP=SIN(YP(3))                                               POWE0051  13
      SIPMP=SIN(YP(3)-PO)                                          POWE0052  14
      COPMP=COS(YP(3)-PO)                                          POWE0053  15
  504 RP2=    (RO2+YP(1)**2-2.0*YP(1)*RO*(SITO*S*COPMP             POWE0054
     1+COTO*C))                                                    POWE0055
    2 RP=SQRT(RP2)                                                 POWE0056  18
      COTP=(RCT-RO*COTO)/RP                                        POWE0057
```

```
   10 SITP=SQRT(1.-COTP**2)                                          POWE0058    20
  505 COPP=(RST*COP-RO*SITO*COPO)/RP/SITP                            POWE0059
  506 DRPUR=(YP(1)-RO*(SITO*S*COPMP+COTO*C))/RP                      POWE0060
      DRPDT=-RO*YP(1)*(SITO*C*COPMP-COTO*S)/RP                       POWE0061
  507 DRPUP=RO*YP(1)*SITO*S*SIPMP/RP                                 POWE0062
  508 A(1,1)=YP(1)-RO*(SITO*S*COPMP+COTO*C)                          POWE0063
      A(1,2)=RO*(RST*COTO-RCT*SITO*COPMP)                            POWE0064
      A(1,3)=RST*RO*SITO*SIPMP                                       POWE0065
      A(2,1)=S*COP                                                   POWE0066
      A(2,2)=RCT*COP                                                 POWE0067
      A(2,3)=-RST*SIP                                                POWE0068
      A(3,1)=C                                                       POWE0069
      A(3,2)=-RST                                                    POWE0070
      A(3,3)=0.0                                                     POWE0071
      B(1,1)=RP                                                      POWE0072
      B(2,1)=SITP*COPP                                               POWE0073
      B(3,1)=COTP                                                    POWE0074
      B(1,2)=0.0                                                     POWE0075
  509 B(2,2)=RP*COTP*COPP                                            POWE0076
  510 CALL MINV(3,A,B)                                               POWE0077    27
      DRDRP=A(1,1)                                                   POWE0078
      DTDRP=A(2,1)                                                   POWE0079
  511 DPDRP=A(3,1)                                                   POWE0080
C                                                                    POWE0081
C     CALCULATE INTERMEDIATE DERIVATIVES                             POWE0082
C                                                                    POWE0083
  512 D2MY1R = -(FHCSP2*DCPDY1/F2*DFHDR-YC*DCPDY1*                   POWE0084
     1           (DCPDR/SINPSI*COSPSI-DNDR/TERMC1)-                  POWE0085
     2            FH**2*SINPSI/F2*D2SY1R)/TERM                       POWE0086
      D2MY2T=-(FHCSP2*DCPDY2/F2*DFHDT-YC*DCPDY2*                     POWE0087
     1(DCPDT/SINPSI*COSPSI/SINPSI-DNDT/TERMC1)-                      POWE0088
     2FH**2*SINPSI/F2*D2SY2T)/TERM                                   POWE0089
  513 D2MY3P=-(FHCSP2*DCPDY3/F2*DFHDP-YC*DCPDY3*                     POWE0090
     1           (DCPDP/SINPSI*COSPSI-DNDP/TERMC1)-                  POWE0091
     2            FH**2*SINPSI/F2*D2SY3P)/TERM                       POWE0092
C                                                                    POWE0093
  514 D2AY1R= -D2MY1R + (DMDR*DMDY1+EM * D2MY1R                      POWE0094
     1           +(FHCSP2/F2*DFHDR+Y2*DCPDR)*DCPDY1+YC*D2CY1R        POWE0095
     2           -(EM*DMDR+DFHDR*F2C+YC*DCPDR)                       POWE0096
     3           *(EM*DMDY1+YC*DCPDY1)/EMRAD2) / EMRAD               POWE0097
      D2AY2T=-D2MY2T+(DMDT*DMDY2+EM*D2MY2T+                          POWE0098
     1(FHCSP2/F2*DFHDT+Y2*DCPDT)*DCPDY2+YC*D2CY2T                    POWE0099
     2-(EM*DMDT+DFHDT*F2C+YC*DCPDT)                                  POWE0100
     3*(EM*DMDY2+YC*DCPDY2)/EMRAD2)/EMRAD                            POWE0101
  515 D2AY3P= -D2MY3P + (DMDP*DMDY3+EM * D2MY3P                      POWE0102
     1           +(FHCSP2/F2*DFHDP+Y2*DCPDP)*DCPDY3+YC*D2CY3P        POWE0103
     2           -(EM*DMDP+DFHDP*F2C+YC*DCPDP)                       POWE0104
     3           *(EM*DMDY3+YC*DCPDY3)/EMRAD2) / EMRAD               POWE0105
C                                                                    POWE0106
C     DERIVATIVES OF A WITH RESPECT TO,Y1,Y2,Y3,PHI,THETA,R          POWE0107
C                                                                    POWE0108
  516 DADY1 = -DMDY1+(EM*DMDY1+YC*DCPDY1)/EMRAD                      POWE0109
      DADY2 = -DMDY2+(EM*DMDY2+YC*DCPDY2)/EMRAD                      POWE0110
      DADY3 = -DMDY3+(EM*DMDY3+YC*DCPDY3)/EMRAD                      POWE0111
      DADR= -DMDR+(EM*DMDR +F2C * DFHDR +YC *DCPDR)/ EMRAD           POWE0112
      DADT  = -DMDT+(EM*DMDT+F2C*DFHDT+YC*                           POWE0113
```

```
      1DCPDT)/EMRAD                                              POWE0114
  517 DADP= -DMUP+(EM*DMDP +F2C * DFHDP +YC *DCPDP)/ EMRAD       POWE0115
  518 DBDR=DADR+DMDR                                              POWE0116
      DBDT=DADT+DMDT                                              POWE0117
      DBDP=DADP+DMDP                                              POWE0118
  519 DBDSI=DMDDSI+DMDSI                                          POWE0119
C                                                                 POWE0120
  520 D2MDSR=(FHCSP2*SINPSI*DFHDR+FH*FH*(-COSPS2/SINPSI+SINPSI)*  POWE0121
     1         DCPDR+FHCSP2*FH/C1*SINPSI/TERM*DNDR)/F2/TERM       POWE0122
      D2MDST=(FHCSP2*SINPSI*DFHDT+FH*FH*(-COSPS2/SINPSI+SINPSI)*  POWE0123
     1         DCPDT+FHCSP2*FH/C1*SINPSI/TERM*DNDT)/F2/TERM       POWE0124
  521 D2MDSP=(FHCSP2*SINPSI*DFHDP+FH*FH*(-COSPS2/SINPSI+SINPSI)*  POWE0125
     1         DCPDP+FHCSP2*FH/C1*SINPSI/TERM*DNDP)/F2/TERM       POWE0126
C                                                                 POWE0127
C     SECOND DERIVATIVES OF MU                                    POWE0128
C                                                                 POWE0129
  522 D2UDSR= -DMUDSI/EMU*DMUDR-DMUDR/EMD*DMDDSI + XTERM *        POWE0130
     1         (-D2MDSR-DADR/EMRAD*DBDSI+(DMDSI*DMUR+EM*D2MDSR    POWE0131
     2         -2.*F2C/COSPSI*SINPSI*DFHDR-Y2*SINPSI*DCPDR +YC* COSPSI POWE0132
     3         /SINPSI*DCPDR)/EMRAD)-XTERM*DADR/EMD*DMDDSI        POWE0133
      D2UDST=-DMUDSI/EMU*DMUDT-DMUDT/EMD*DMDDSI+XTERM*            POWE0134
     1(-D2MDST-DBDT/EMRAD*DBDSI+(DMDSI*DMUT+EM*D2MDST             POWE0135
     2-2.*F2C/COSPSI*SINPSI*DFHDT-Y2*SINPSI*DCPDT+YC*COSPST       POWE0136
     3/SINPSI*DCPDT)/EMRAD)-XTERM*DADT/EMU*DMDDSI                 POWE0137
      D2UDSP= -DMUDSI/EMU*DMUDP-DMUDP/EMD*DMDDSI + XTERM *        POWE0138
     1         (-D2MDSP+(DMDSI*DMDP+EM*D2MDSP                     POWE0139
     2         -2.*F2C/COSPSI*SINPSI*DFHDP-Y2*SINPSI*DCPDP  +YC* COSPSI POWE0140
     3         /SINPSI*DCPDP)/EMRAD -DBDP/EMRAD*DBDSI-DADP/EMD*DMDDSI) POWE0141
      D2UY1R =((DADY1/AA2C1)*(DNDR-2.*EN/EMU*DADR)                POWE0142
     1+D2AY1R*ENDA2C-2.*DMUDR*DMUDY1)/2./EMU                      POWE0143
      D2UY2T = ((DADY2/AA2C1)*(DNDT-2.*EN/EMD*DADT)               POWE0144
     1+ENDA2C*D2AY2T-2.*DMUDT*DMUDY2)/2./EMU                      POWE0145
  523 D2UY3P = ((DNDP/AA2C1-2.*ENDA2C*DADP/EMU)*DADY3+            POWE0146
     1ENDA2C*D2AY3P-2.*DMUDP*DMUDY3)/(2.*EMU)                     POWE0147
C                                                                 POWE0148
  524 YPEMDU = YP(4)-EMU*DMUDY1                                   POWE0149
      YP2MDU = YP(5)-EMU*DMUDY2                                   POWE0150
  525 YP3MDU = YP(6)-EMU*DMUDY3                                   POWE0151
C                                                                 POWE0152
  526 XTEM2=EMUS+DMUDSI**2                                        POWE0153
      XTEM=SQRT(XTEM2)                                            POWE0154   45
      DMUDRP=DMUDR*DRDRP+DMUDT*DTDRP+DMUDP*DPDRP                  POWE0155
      DUDSRP=D2UDSR*DRDRP+D2UDST*DTDRP+D2UDSP*DPDRP               POWE0156
      DUY1RP=D2UY1R*DRDRP                                         POWE0157
      DUY2RP=D2UY2T*DTDRP                                         POWE0158
  527 DUY3RP=D2UY3P*DPDRP                                         POWE0159
  528 RDOTP=(DRPDR*YPEMDU+DRPDT*YP2MDU/YP(1)+DRPDP*YP3MDU/RST)    POWE0160
     1/XTEM                                                       POWE0161
  529 DEL2S=(2.0*EMU/RP+DMUDRP)*RDOTP-EMU*RDOTP/XTEM2*(EMU*DMUDRP POWE0162
     1+DMUDSI*DUDSRP)-EMU/XTEM*(DRPDR*(DMUDRP*DMUDY1+EMU*DUY1RP)+DRPDT/YPOWE0163
     2P(1)*(YP2MDU/YP(1)+DRDRP+DMUDRP*DMUDY2+EMU*DUY2RP)+DRPDP/RST* POWE0164
     3((1.0/YP(1)*DRDRP+C/S*DTDRP)*YP3MDU+DMUDRP*DMUDY3+EMU*DUY3RP)) POWE0165
  530 YD(11)=DEL2S/EMUS/COSA                                      POWE0166
      RETURN                                                      POWE0167
      END                                                         POWE0168
```

$IBFTC FORC

```
      SUBROUTINE FORCE                                                  FORC0002
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       FORC0003
     1              PMIN,     PRNT,     RELERR,   AO,       RO,         FORC0004
     2              RQ,       THETAO,   PHIO,     PLUS,     NPOWER,     FORC0005
     3              NPLOT,    J,        NUAR,     N1,       FN,         FORC0006
     4              DNDR,     DNDI,     DNDP,     EMU,      RTYSQR,     FORC0007
     5              F,        F2,       C1,       FH,       COSPSI,     FORC0008
     6              SINPSI,   DFHDR,    DFHDI,    DCPDI,    DCPDY1,     FORC0009
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   FMUS,       FORC0010
     8              N,        GNU,      MUFLAG                          FORC0011
      COMMON  /HBANK1/ MORDER,     NOHALF,     NODOUR,     HBANK,     NOEQ,  FORC0012
     1                 FINVP,      FINVPI,     YO(11),     YD(11),    MA(260)FORC0013
  100 YNRMLZ=EMU/RTYSQR                                                 FORC0014
  101 YO(4)=YNRMLZ*YO(4)                                                FORC0015
      YO(5)=YNRMLZ*YO(5)                                                FORC0016
  102 YO(6)=YNRMLZ*YO(6)                                                FORC0017
      RETURN                                                            FORC0018
      END                                                               FORC0019
```

$IBFTC COL

```
                                                                   02/06/69              PAGE
        COL       -  EFN   SOURCE STATEMENT  -  IFN(S)  -

      SUBROUTINE COLL( Y01,Y02,Y03,GNU )
C
C
C     RADIUS OF WAVE FRONT IN KM                   Y01
C     COLATITUDE OF WAVE FRONT IN RADIANS          Y02
C     LONGITUDE  OF WAVE FRONT IN RADIANS          Y03
C     COLLISION FREQUENCY                          GNU
C
C
      DIMENSION  A(6) , B(6) ,
     1           C(3) , D(3)
      DATA  A /  5.0562E 0,  -3.7482E-2 ,  1.3864E-4 ,
     1          -1.4777E-7,  -4.8192E-1 , -2.7021E-1 /
      DATA  B /  3.2512E-2,  -8.8470E-3 ,  8.5410E-5 ,
     1          -1.5422E-7,  -1.4700E-2 ,  6.5037E-1 /
      DATA  C / -3.5818E-1,   1.1250E 0 , -8.8344E-1 /
      DATA  D / -1.7828E-1,   5.5997E 0 ,  5.6028E 0 /                COLL0020
C                                                                     COLL0021
C
      X = Y01 - 6378.0
    4 IF(X-100.) 5,5,6                                                COLL0023
    5 GNU=12.03527-.07392*X                                           COLL0024
    9 GNU=10.**GNU                                                    COLL0025     6
      RETURN                                                          COLL0026
    6 COEFF=(C(1)*Y02+C(2))*Y02+C(3)+((D(1)*Y02+D(2))*Y02             COLL0027
    1  +D(3))*COS(Y03)                                                COLL0028     8
   65 IF(X-475.) 7,8,8                                                COLL0029
    7 X=X-100.                                                        COLL0030
      XFAC=X*.015708                                                  COLL0031
      S=SIN(XFAC)                                                     COLL0032    12
      E=COS(XFAC)                                                     COLL0033    13
   75 GNU=((A(4)*X+A(3))*X+A(2))*X+A(1)+A(5)*E+A(6)*S+(((B(4)*X+B(3))*X COLL0034
     1+B(2))*X+B(1)+B(5)*E+B(6)*S)*COEFF                              COLL0035
      GO TO 9                                                         COLL0036
    8 X=X-475.                                                        COLL0037
   85 GNU=2.3653-.0030266*X+(.3195+.0000536*X)*COEFF                  COLL0038
      GO TO 9                                                         COLL0039
      END                                                             COLL0040
```

$IBFTC CSI

```
      SUBROUTINE CSINT (XX,CI,SI)                              CST10002
 5001 DIMENSION  A0(4),A2(4),A4(4),A6(4),BP(4)                 CST10003
      DATA  A0/38.102495,157.10542,21.821899,449.69033/,       CST10004
     1       A2/335.67732,570.23628,352.01850,1114.9789/,       CST10005
     1       A4/265.18703,322.62491,302.75787,482.48598/,       CST10006
     3       A6/38.027264,40.021433,42.242855,48.196927/        CST10007
      X = ABS (XX)                                             CST10008
    5 M=1                                                      CST10009
    6 MM=1                                                     CST10010
    7 IF (X-16.0)      400,4,4                                 CST10011
    4 POFX=0.0                                                 CST10012
      QOFX=0.0                                                 CST10013
      POLD=0.0                                                 CST10014
      QOLD=0.0                                                 CST10015
      S GN = +1.0                                              CST10016
      ERROR = 1.0 E -8                                         CST10017
   20 DO 40   N=1,15                                           CST10018
      NN=2*N-2                                                 CST10019
      NNN=NN+1                                                 CST10020
      BN=2*N                                                   CST10021
      CN=BN-1.0                                                CST10022
   21 IF  (M)      30 ,22, 22                                  CST10023
   22 POFX = POLD + S GN*TOR(NN)/X**CN                         CST10024   16   17
   24 IF (ABS (ABS (POLD/POFX)-1.0)-ERROR)    25, 25,26        CST10025
   25  M=-1                                                    CST10026
      GO TO 30                                                 CST10027
   26 POLD=POFX                                                CST10028
   30 IF (MM)      35,31 ,31                                   CST10029
   31 QOFX = QOFX + S GN*TOR(NNN)/X**BN                        CST10030   26   27
   33 IF (ABS (ABS (QOLD/QOFX)-1.0)-ERROR)    34, 34, 36       CST10031
   34 MM = -1                                                  CST10032
   35 IF (M) 41,40,40                                          CST10033
   36 QOLD = QOFX                                              CST10034
   40 S GN = -S GN                                             CST10035
   41 SI=1.5707963-POFX*COS (X)-QOFX*SIN (X)                   CST10036   38   39
   42 CI=POFX*SIN (X)-QOFX*COS (X)                             CST10037   41   42
      GO TO 500                                                CST10038
  400 IF (X)  401,402,409                                      CST10039
  401  WRITE(6,1000)                                           CST10040   46
 1000 FORMAT(1H15X22HX LESS THAN 0. IN CS(1)                   CST10041
      CALL EXIT                                                CST10042   47
  402 SI=0.0                                                   CST10043
  403 CI=-9.99E+30                                             CST10044
  404 RETURN                                                   CST10045
  409 IF (X-1.0)  410,5002,5002                                CST10046
  410 P = X                                                    CST10047
      PP = X**2                                                CST10048
      PPP = PP**2                                              CST10049
      SI = X*(1.0-PP/18.0)                                     CST10050
  411 Q = 0.5*PP                                               CST10051
      CI = 0.57721567 +ALOG (X) + 0.25*PP*(-1.0+PP/24.0)       CST10052   55
   55 ERROR =  1.0 E  -15                                      CST10053
  420 DO 440 N =2,50                                           CST10054
      AN = N                                                   CST10055
      BN = 2.0*AN                                              CST10056
```

```
      CN = BN*2.0                                                  CST10057
  421 IF (M) 430,422,422                                           CST10058
  422 P = P*PPP/((CN-3.0)*(CN-4.0)*(CN-5.0)*(CN-6.0))              CST10059
      TERM = P*(1.0/(CN-3.0)-PP/(((CN-1.0)**2)*(CN-2.0)))          CST10060
      IF (ABS (TERM)-ERROR)   425,425,424                          CST10061
  424 SI = SI + TERM                                               CST10062
      GO TO 430                                                    CST10063
  425 M=-1                                                         CST10064
  430 IF (MM)  435,431,431                                         CST10065
  431 Q = Q*PPP/((CN-2.0)*(CN-3.0)*(CN-4.0)*(CN-5.0))              CST10066
      TERM = -Q*(1.0/(CN-2.0)-PP/((CN-1.0)*CN**2))                 CST10067
      IF (ABS (TERM) - ERROR )  434,434,433                        CST10068
  433 CI = CI + TERM                                               CST10069
      GO TO 435                                                    CST10070
  434 MM=-1                                                        CST10071
  435 IF (M)    500,440,440                                        CST10072
  440 CONTINUE                                                     CST10073
  500 IF(XX)  501,503,503                                          CST10074
  501 SI=-SI                                                       CST10075
  503 RETURN                                                       CST10076
 5002 CONTINUE                                                     CST10077
 5005 XSQ=X**2                                                     CST10078
      REC=1.0/XSQ                                                  CST10079
 5006 DO 5007 I=1,4                                                CST10080
 5007 QP(I)=REC*(REC*(REC*A0(I)+A2(I))+A4(I))+A6(I)+XSQ            CST10081
 5008 P = QP(1)/(QP(2)*X)                                          CST10082
      Q = QP(3)*REC/QP(4)                                          CST10083
 5009 CC = COS (X)                                                 CST10084   100
      SS = SIN (X)                                                 CST10085   101
 5010 SI = 1.5707963 -P*CC-Q*SS                                    CST10086
      CI = P*SS-Q*CC                                               CST10087
 5011 GO TO 500                                                    CST10088
      END                                                          CST10089
```

$IBFTC POLA

```
C                                                                       POLA0002
C     SUBROUTINE TO COMPUTE POLARIZATION                                POLA0003
C                                                                       POLA0004
      SUBROUTINE POLAR                                                  POLA0005
C                                                                       POLA0006
      COMMON /DATA/ RMAX,     RMIN,     TMAX,     TMIN,     PMAX,       POLA0007
     1              PMIN,     PRNT,     RELERR,   AO,       BO,         POLA0008
     2              RO,       THETAO,   PHIO,     PLUS,     NPOWER,     POLA0009
     3              NPLOT,    J,        NUAR,     N1,       FN,         POLA0010
     4              DNDR,     DNDT,     DNDP,     EMU,      RTYSQR,     POLA0011
     5              F,        F2,       C1,       FH,       COSPSI,     POLA0012
     6              SINPSI,   DFHDR,    DFHDT,    DCPDT,    DCPDY1,     POLA0013
     7              DCPDY2,   DCPDY3,   SP2,      EMUINT,   EMUS,       POLA0014
     8              N,        GNU,      MUFLAG,   NTEST                 POLA0015
C                                                                       POLA0016
      COMMON /HBANK1/ MORDER,   NOHALF,   NODOUB,   HBANK,    NOEQ,     POLA0017
     1              FINVP,    FINVPI,   YO(11),   YD(11),   MA(260)POLA0018
C                                                                       POLA0019
      COMMON / CRSR / C, RCT,S,RST,Z,EM,TERM,TERM2,RMOD,RARG,YO6        POLA0020
C                                                                       POLA0021
      COMPLEX R,XMZ                                                     POLA0022
      Y      =  FH / F
      YL     =  Y * COSPSI
      YT     =  Y * SINPSI
      YL2    =  YL * YL
      YT2        =  ( YT * YT ) / 2.0
      YT4        =  YT2 * YT2
      XMZ=CMPLX(TERM,-Z)                                                POLA0029
  101 R=CMPLX(0.,-1./YL)*(YT2/XMZ-PLUS*CSQRT(YT4/XMZ+YL2))              POLA0030    3
  102 RMOD=CABS(R)                                                      POLA0031    5
  103 RARG=ATAN2(AIMAG(R),REAL(R))                                      POLA0032    7
      RETURN                                                            POLA0033
      END                                                               POLA0034
```

$IBETC 10

```
      FUNCTION TOR(N)                                  TOR 0002
      X = N                                            TOR 0003
      TEMP=N**N                                        TOR 0004   2
      NOR=TEMP*EXP(-X)*SQRT(6.2831853*X)+.1            TOR 0005   3     4
      TOR=NOR                                          TOR 0006
      RETURN                                           TOR 0007
      END                                              TOR 0008
```

```
      SUBROUTINE MINV(N,A,B)                                           MINV0004
      DIMENSION A(3,3),B(3,3),IPIV(3)                                  MINV0005
      DO 1 I=1,N                                                       MINV0006
    1 IPIV(I)=I                                                        MINV0007
      NMI=N-1                                                          MINV0008
      DO 2 I=1,NMI                                                     MINV0009
      IMAX = I                                                         MINV0010
      IPI = I+1                                                        MINV0011
      DO 5 J=IPI,N                                                     MINV0012
      IPJ = IPIV(J)                                                    MINV0013
      IPMAX =IPIV(IMAX)                                                MINV0014
      IF(ABS(A(IPJ,I))-ABS(A(IPMAX,I))) 5,5,6                          MINV0015
    6 IMAX=J                                                           MINV0016
    5 CONTINUE                                                         MINV0017
      TEMP=IPIV(IMAX)                                                  MINV0018
      IPIV(IMAX)=IPIV(I)                                               MINV0019
      IPIV(I)=TEMP                                                     MINV0020
      IPIVI=IPIV(I)                                                    MINV0021
      A(IPIVI,I)=1.0/A(IPIVI,I)                                        MINV0022
      DO 7 J=IPI,N                                                     MINV0023
      IPJ = IPIV(J)                                                    MINV0024
      A(IPJ,I)=A(IPJ,I)*A(IPIVI,I)                                     MINV0025
      DO 8 K=IPI,N                                                     MINV0026
    8 A(IPJ,K)=A(IPJ,K)-A(IPJ,I)*A(IPIVI,K)                            MINV0027
    7 CONTINUE                                                         MINV0028
    2 CONTINUE                                                         MINV0029
      IPN=IPIV(N)                                                      MINV0030
      A(IPN,N)=1.0/A(IPN,N)                                            MINV0031
      DO 9 I=1,NMI                                                     MINV0032
      IPIVI=IPIV(I)                                                    MINV0033
      IPI=I+1                                                          MINV0034
      DO 10 J=IPI,N                                                    MINV0035
      IPJ=IPIV(J)                                                      MINV0036
      DO 11 K=1,N                                                      MINV0037
   11 B(IPJ,K)=B(IPJ,K)-A(IPJ,I)*B(IPIVI,K)                            MINV0038
   10 CONTINUE                                                         MINV0039
    9 CONTINUE                                                         MINV0040
      DO 12 I=1,N                                                      MINV0041
      ICOMP=N-I+1                                                      MINV0042
      IPCO=IPIV(ICOMP)                                                 MINV0043
      ICOPI=ICOMP+1                                                    MINV0044
      IF(N-ICOPI) 13,14,14                                             MINV0045
   14 DO 15 J=ICOPI,N                                                  MINV0046
      IPJ=IPIV(J)                                                      MINV0047
      DO 16 K=1,N                                                      MINV0048
   16 B(IPCO,K)=B(IPCO,K)-A(IPCO,J)*B(IPJ,K)                           MINV0049
   15 CONTINUE                                                         MINV0050
   13 DO 17 K=1,N                                                      MINV0051
   17 B(IPCO,K)=A(IPCO,ICOMP)*B(IPCO,K)                                MINV0052
   12 CONTINUE                                                         MINV0053
      DO 30 I=1,N                                                      MINV0054
      IPIVI=IPIV(I)                                                    MINV0055
      DO 30 J=1,N                                                      MINV0056
   30 A(I,J)=B(IPIVI,J)                                                MINV0057
      RETURN                                                           MINV0058
```

```
      END                                                          MINV0059
```

MAIN PROGRAM

COMMON VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
COMMON BLOCK			DATA	ORIGIN	00001	LENGTH	00054	
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	FMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DEHUR	00037	R	DEHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	FMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NIEST	00053	I			
COMMON BLOCK			HBANK1	ORIGIN	00055	LENGTH	00441	
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						
COMMON BLOCK			CRSR	ORIGIN	00516	LENGTH	00013	
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			
COMMON BLOCK			NEW	ORIGIN	00531	LENGTH	00002	
PLOTO	00000	R	ROOT	00001	R			
COMMON BLOCK			EPSTN	ORIGIN	00533	LENGTH	00002	
EPSTIN	00000	R	PROPT	00001	R			
COMMON BLOCK			RSN	ORIGIN	00535	LENGTH	00001	
IRSN	00000	I						
COMMON BLOCK			GAUSS	ORIGIN	00536	LENGTH	00007	
YSQUAR	00000	R	DCPUR	00001	R	DCPDP	00002	R
DFHDP	00003	R	FIT	00004	R	DNMNTR	00005	R
DEL2S	00006	R						
COMMON BLOCK			POWLOS	ORIGIN	00545	LENGTH	00023	
COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDSI	00010	R
DMDDSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R

```
                                                                                 02/06/69                                PAGE
      MAIN                                              STORAGE  MAP
DMUUY3      00017         R              DMUUS1       00020        R              END         00021        R
EMRAD       00022         R

                COMMON BLOCK      RECT                ORIGIN       00570              LENGTH      13565
DD          00000         R              SUA          05672        R              LB          13564        I

                COMMON BLOCK      ROOTS               ORIGIN       14355              LENGTH      00002
JUMP        00000         I              NYD1         00001        I

                COMMON BLOCK      CONST               ORIGIN       14357              LENGTH      00007
ORDER       00000         R              EUBAR        00001        R              FLRAR       00002        R
YCLOW       00003         R              HMAXT        00004        R              HMINT       00005        R
KD          00006         I

                COMMON BLOCK      GRAPH1              ORIGIN       14366              LENGTH      00010
XMAX1       00000         R              XMIN1        00001        R              YMAX1       00002        R
YMIN1       00003         R              DATE         00004        R

                COMMON BLOCK      GRAPH0              ORIGIN       14376              LENGTH      00023
XMAX0       00000         R              XMIN0        00001        R              YMAX0       00002        R
YMIN0       00003         R              PLT          00004        R

                                      UNDIMENSIONED PROGRAM VARIABLES

SYMBOL      LOCATION      TYPE           SYMBOL       LOCATION     TYPE           SYMBOL      LOCATION     TYPE
ND          14421         I              PRNTO        14422        R              PLOIT       14423        R
TESTJ       14424         R              I1           14425        I              NRTN        14426        I
NTRG        14427         I              YADU         14430        R              X           14431        R
YT          14432         R              YT2          14433        R              YL          14434        R
YL2         14435         R              YLY1         14436        R              DMD         14437        R
DMN1        14440         R              DMN2         14441        R              DMT1        14442        R
DMT2        14443         R              DMUN1        14444        R              DMUN2       14445        R
DMD1        14446         R              DMUU1        14447        R              DMUN3       14450        R
DMDF        14451         R              DMUUF        14452        R              EMZ         14453        R
A           14454         R              B            14455        R              U           14456        R
V           14457         R              W            14460        R              CAPPA       14461        R
THETA       14462         R              RAD          14463        R              EMUPI       14464        R
PI          14465         R              CIMUPI       14466        R              SIMUPI      14467        R
PI2         14470         R              CIM2PI       14471        R              SIM2PI      14472        R
EMUPI2      14473         R              PI02         14474        R              DENOM       14475        R
RO2         14476         R              R2           14477        R              PP2         14500        R
RP          14501         R              PSI          14502        R

                                              ENTRY POINTS

     ......     SECTION     15

                                            SUBROUTINES CALLED

     INPUT      SECTION     16              ON           SECTION      17              OFF         SECTION      18
     SMARK      SECTION     19              COS          SECTION      20              SIN         SECTION      21
     SQRT       SECTION     22              DENSE        SECTION      23              .FWRD.      SECTION      24
     COLL       SECTION     25              FIELD        SECTION      26              FORCE       SECTION      27
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POWERL	SECTION	28	TRA14	SECTION	29	OUTPUT	SECTION	30
CSINT	SECTION	31	ALOG	SECTION	32	ARCOS	SECTION	33
TRA24	SECTION	34	.EXIT.	SECTION	35	.FXEM.	SECTION	36
.UN06.	SECTION	37	.FFIL.	SECTION	38	.FCNV.	SECTION	39
CC.1	SECTION	40	CC.2	SECTION	41	CC.3	SECTION	42
CC.4	SECTION	43	SYSLOC	SECTION	44			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
102	1A	14562	39	6A	14571	104	11A	14576
20	21A	14623	105	26A	14631	1047	31A	14644
106	33A	14705	40	87A	15755	41	34A	14717
42	89A	15760	43	152A	16417	50	41A	14747
107	45A	14756	2000	49A	14772	2001	51A	15003
2002	FORMAT	14543	4001	99A	16026	108	52A	15003
110	55A	15021	2003	60A	15102	2004	62A	15113
2005	FORMAT	14550	116	63A	15113	117	65A	15120
118	67A	15123	119	68A	15163	120	69A	15170
121	70A	15245	122	71A	15254	123	72A	15414
124	73A	15435	125	76A	15534	126	77A	15552
127	78A	15571	128	79A	15606	129	81A	15622
130	82A	15744	131	83A	15747	132	92A	15770
133	94A	15774	44	95A	16014	45	109A	16052
908	97A	16022	47	107A	16044	46	143A	16376
4000	105A	16041	134	111A	16056	135	113A	16062
136	115A	16066	1046	119A	16100	137	121A	16107
140	125A	16131	141	137A	16325	142	144A	16400
143	145A	16401	144	147A	16405	145	149A	16411
146	150A	16414	1000	FORMAT	14555			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 16454.

SUBROUTINE INPUT

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	A0	00010	R
B0	00011	R	R0	00012	R	THETA0	00013	R
PHI0	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	FMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DEHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	FMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	Y0	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK CHSH ORIGIN 00515 LENGTH 00013

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	EM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

COMMON BLOCK CONST ORIGIN 00530 LENGTH 00007

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
ORDER	00000	R	EUBAR	00001	R	FLBAR	00002	R
YCLOW	00003	R	HMAXT	00004	R	HMINT	00005	R
KD	00006	I						

COMMON BLOCK NEW ORIGIN 00537 LENGTH 00002

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
PLOT0	00000	R	ROOT	00001	R

COMMON BLOCK RECT ORIGIN 00541 LENGTH 13565

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
DD	00000	R	SOA	05672	R	LB	13564	I

COMMON BLOCK RSN ORIGIN 14326 LENGTH 00001

SYMBOL	LOCATION	TYPE
IRSN	00000	I

COMMON BLOCK RBLK1 ORIGIN 14327 LENGTH 00005

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
STZM5	00000	R	HPRIME	00001	R	PKDELN	00002	R
AMBDL	00003	R	H0	00004	R			

COMMON BLOCK GRAPH0 ORIGIN 14334 LENGTH 00023

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R

YMIN0	00003	R	PLT	00004	R

COMMON BLOCK GRAPH1 ORIGIN 14357 LENGTH 00010

XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			

COMMON BLOCK GRAPH2 ORIGIN 14367 LENGTH 00024

TITLE	00000	R

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
V	14413	R	W	14416	R	D	14421	R

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
LAST	14457	I	NTITLE	14460	I	NCONST	14461	I
LIMITS	14462	I	RAD	14463	R	RPERD	14464	R
REARTH	14465	R	DELAO	14466	R	PRINT	14467	R
PLINT	14470	R	MODE	14471	I	JTEST	14472	I
NOVER	14473	I	NAUTO	14474	I	PKFRAC	14475	R
AMBDA	14476	R	THO	14477	R	SNLAM1	14500	R
SNLAM2	14501	R	SNLAM3	14502	R	SNTHO1	14503	R
SNTHO2	14504	R	SNTHO3	14505	R	TNTHO1	14506	R
TNTHO2	14507	R	STSL	14510	R	ZM1	14511	R
ZM2	14512	R	ZM3	14513	R	ZM4	14514	R
ZM5	14515	R	H	14516	R	HPRIM1	14517	R
WALSH1	14520	R	WALSH2	14521	R	WALSH3	14522	R
W1	14523	R	T17	14524	R	FNF	14525	R
ZX	14526	R	ENXR	14527	R	FNY	14530	R
TM	14531	R	FACTOR	14532	R	H1	14533	R
A	14534	R	B	14535	R	Y	14536	R
YO42	14537	R	YO52	14540	R	YO62	14541	R
YSQUAR	14542	R	Y	14543	R	YT	14544	R
YT2	14545	R	YL	14546	R	YL2	14547	R
YLYT	14550	R	EMRAD	14551	R	EMD	14552	R
EMUZ	14553	R	EL	14554	R			

ENTRY POINTS

INPUT	SECTION	13

SUBROUTINES CALLED

.FRDU.	SECTION	14	.FRDD.	SECTION	15	.FSLI.	SECTION	16
SIN	SECTION	17	TAN	SECTION	18	SQRT	SECTION	19
ATAN	SECTION	20	EXP	SECTION	21	COS	SECTION	22
DENSE	SECTION	23	.FWRD.	SECTION	24	FIELD	SECTION	25
CALCO1	SECTION	26	CALCO3	SECTION	27	.FSLO.	SECTION	28
CALCO2	SECTION	29	.EXIT.	SECTION	30	.UN05.	SECTION	31
.FRTN.	SECTION	32	.FCNV.	SECTION	33	.UN06.	SECTION	34

.FFIL.	SECTION	35	E.1	SECTION	36	E.2	SECTION	37
E.3	SECTION	38	E.4	SECTION	39	CC.1	SECTION	40
CC.2	SECTION	41	CC.3	SECTION	42	CC.4	SECTION	43
SYSLOC	SECTION	44						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
781	FORMAT	14611	981	FORMAT	14613	500	FORMAT	14615
501	FORMAT	14616	999	FORMAT	14617	1000	FORMAT	14623
1001	FORMAT	14711	1002	FORMAT	14764	1003	FORMAT	15065
11	90A	16536	60	30A	15643	100	38A	15730
40	46A	15776	41	48A	16017	112	54A	16146
2000	58A	16162	2001	60A	16175	2002	FORMAT	15175
115	64A	16234	2003	69A	16315	2004	71A	16330
2005	FORMAT	15202	9	83A	16377	62	78A	16370
63	81A	16374						

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 16567.

SUBROUTINE OUTPUT

COMMON VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
COMMON BLOCK			EPSIN	ORIGIN	00001	LENGTH	00002	
EPSTIN	00000	R	PROPT	00001	R			
COMMON BLOCK			DATA	ORIGIN	00003	LENGTH	00053	
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWFR	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						
COMMON BLOCK			HBANK1	ORIGIN	00056	LENGTH	00441	
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						
COMMON BLOCK			CRSR	ORIGIN	00517	LENGTH	00013	
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			
COMMON BLOCK			GAUSS	ORIGIN	00532	LENGTH	00007	
YSQUAR	00000	R	DCPDR	00001	R	DCPDP	00002	R
DFHDP	00003	R	F1T	00004	R	DNMNTR	00005	R
DEL2S	00006	R						
COMMON BLOCK			POWLOS	ORIGIN	00541	LENGTH	00023	
COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDSI	00010	R
DMDUSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R
DMUDY3	00017	R	DMUDSI	00020	R	EMD	00021	R
EMRAD	00022	R						
COMMON BLOCK			GRAPH2	ORIGIN	00564	LENGTH	00024	
TITLE	00000	R						

		COMMON BLOCK	RECI		ORIGIN	00610	LENGTH	00003
DD	00000	R		SOA	00001	R	LB	00002	I
		COMMON BLOCK	RDOTS		ORIGIN	00613	LENGTH	00002
JUMP	00000	I		NYD1	00001	I		

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XX	00615	R	YY	01603	R	DATE	02571	R
PLT	02575	R						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
THETA	02614	R	PHI	02615	R	DSHIFT	02616	R
VALCRI	02617	R	LL	02620	I	C2	02621	R
YOSQR	02622	R	GROUFL	02623	R	PL	02624	R

ENTRY POINTS

OUTPUT SECTION 11

SUBROUTINES CALLED

SQRT	SECTION	12	.FWRD.	SECTION	13	.FSLO.	SECTION	14
POLAR	SECTION	15	ALOG10	SECTION	16	EXP	SECTION	17
CALC04	SECTION	18	CALC05	SECTION	19	.FXEM.	SECTION	20
.UN06.	SECTION	21	.FFIL.	SECTION	22	.FCNV.	SECTION	23
SYSLOC	SECTION	24						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
200	2A	03021	201	3A	03027	101	15A	03102
202	8A	03070	203	9A	03072	100	23A	03125
204	12A	03076	206	19A	03112	46	70A	03454
29	79A	03500	26	29A	03143	207	26A	03131
209	32A	03147	27	36A	03172	1007	FORMAT	03007
28	34A	03162	1002	FORMAT	02725	210	35A	03170
211	37A	03205	212	38A	03210	213	41A	03216
21	46A	03225	214	44A	03222	22	49A	03250
1003	FORMAT	03003	215	50A	03330	216	51A	03333
40	52A	03353	41	54A	03362	42	56A	03371
43	58A	03400	44	60A	03407	45	62A	03416
47	65A	03427	2040	FORMAT	02657	217	63A	03424
2041	FORMAT	02664	2042	FORMAT	02671	2043	FORMAT	02677
2044	FORMAT	02705	2045	FORMAT	02713	2046	FORMAT	02721

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00000         TRA  OUTPUT          02716         BCI  1,ST FOR        03006         BCI  1,16.7))
02625         ORG  1429            02717         BCI  1, PHI M        03007 1007.   BCI  1,( 1H1
02625 C.0     OCT  000000000001    02720         BCI  1,IN)           03010         BCI  1,, 20X
02626 C.1     OCT  000000000000    02721 2046.   BCI  1,(9HORD        03011         BCI  1,, 20A4
02627 C.2     OCT  000000000000    02722         BCI  1,OT =          03012         BCI  1, )
02630 C.3     OCT  000000000001    02723         BCI  1, E15.6        03013 1A      LDQ  YO+1
02631 C.4     OCT  206712273407    02724         BCI  1, )            03014         FMP  C.4
02632 C.5     OCT  164774272155    02725 1002.   BCI  1,(10X10        03015         STO  THETA
02633 C.6     OCT  000000000002    02726         BCI  1,HPHASE        03016         LDQ  YO+2
02634 C.7     OCT  205517064546    02727         BCI  1, PATH6        03017         FMP  C.4
02635 C.8     OCT  000000000012    02730         BCI  1,X6HRAD        03020         STO  PHI
02636 C.9     OCT  000000000000    02731         BCI  1,IUS10X        03021 2A      LDQ  F
02637 C.10    OCT  000000000764    02732         BCI  1,10HCOL        03022         FMP  C.5
02640 C.11    OCT  157435022421    02733         BCI  1,ATTITUD       03023         XCA
02641 C.12    OCT  000000000015    02734         BCI  1,E6X9HL        03024         FMP  YO+9
02642 C.13    OCT  000000000024    02735         BCI  1,ONGITU        03025         CHS
02643 C.14    OCT  211454000000    02736         BCI  1,DE7X10        03026         STO  DSHIFT
02644 C.15    OCT  204500000000    02737         BCI  1,HARSOR        03027 3A      CLA  DMUDT
02645 C.16    OCT  207550000000    02740         BCI  1,PTION6        03030         FDP  YO
02646 C.17    OCT  202400000000    02741         BCI  1,X10HDO        03031         STQ  N.
02647 C.18    OCT  000000000067    02742         BCI  1,PPLER         03032         CLA  DMUDP
02650 N.      BSS  4               02743         BCI  1,SP6X10        03033         FDP  RCT
02654 RD.     OCT  000000000000    02744         BCI  1,HPOWER        03034         STQ  N.+1
02655         OCT  000000000000    02745         BCI  1, LOSS/        03035         FMP  N.+1
02656 X.1     BSS  1               02746         BCI  1,10X10H        03036         STO  N.+2
02657 2040.   BCI  1,(25HOS        02747         BCI  1,GROUP         03037         LDQ  N.
02660         BCI  1,TOPPED        02750         BCI  1,PATH6X        03040         FMP  N.
02661         BCI  1, ON TE        02751         BCI  1,2HY114        03041         STO  N.+3
02662         BCI  1,ST FOR        02752         BCI  1,X2HY21        03042         LDQ  DMUDR
02663         BCI  1, RMAX)        02753         BCI  1,4X2HY3        03043         FMP  DMUDR
02664 2041.   BCI  1,(25HOS        02754         BCI  1,14X5HM        03044         FAD  N.+3
02665         BCI  1,TOPPED        02755         BCI  1,U**211        03045         FAD  N.+2
02666         BCI  1, ON TE        02756         BCI  1,X4HY**        03046         STO  N.+2
02667         BCI  1,ST FOR        02757         BCI  1,212X10        03047 4A      TSX  SQRT,4
02670         BCI  1, RMIN)        02760         BCI  1,HEPSTE        03050         TXI  *+3,,1
02671 2042.   BCI  1,(30HOS        02761         BCI  1,IN CD/        03051         PZE  4,,LK.DR
02672         BCI  1,TOPPED        02762         BCI  1,10X8HR        03052         PZE  N.+2
02673         BCI  1, ON TE        02763         BCI  1,AY PAT        03053         STO  N.+2
02674         BCI  1,ST FOR        02764         BCI  1,H8X26H        03054         LDQ  F
02675         BCI  1, THETA        02765         BCI  1,POLARI        03055         FMP  C.7
02676         BCI  1, MAX)         02766         BCI  1,ZATION        03056         XCA
02677 2043.   BCI  1,(30HOS        02767         BCI  1, - MOD        03057         FMP  EMUS
02700         BCI  1,TOPPED        02770         BCI  1, AND A        03060         STO  N.+3
02701         BCI  1, ON TE        02771         BCI  1,RG6X6H        03061         CLA  N.+2
02702         BCI  1,ST FOR        02772         BCI  1,DEL MU        03062         FDP  N.+3
02703         BCI  1, THETA        02773         BCI  1,10X1HN        03063         STQ  VALCRT
02704         BCI  1, MIN)         02774         BCI  1,15X2HN        03064         CLA  JUMP
02705 2044.   BCI  1,(28HOS        02775         BCI  1,U14X          03065         SUB  C.6
02706         BCI  1,TOPPED        02776         BCI  1,              03066         TNZ  7A
02707         BCI  1, ON TE        02777         BCI  1,              03067 5A      NULL
02710         BCI  1,ST FOR        03000         BCI  1,11HGRO        03067 6A      TRA  15A
02711         BCI  1, PHI M        03001         BCI  1,UP DEL        03070 7A      NULL
02712         BCI  1,AX)           03002         BCI  1,AY)           03070 8A      CLA  C.3
02713 2045.   BCI  1,(28HOS        03003 1003.   BCI  1,(/6X1P        03071         STO  JUMP
02714         BCI  1,TOPPED        03004         BCI  1,7E16.7        03072 9A      CLA  **
02715         BCI  1, ON TE        03005         BCI  1,/(6X7E        03073         SUB  C.8
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03074        TZE   11A
03075 10A    TRA   23A
03076 11A    NULL
03076 12A    CLA   N
03077        SUB   C.9
03100        TNZ   14A
03101 13A    TRA   OUTPUT,1
03102 14A    NULL
03102 15A    CLA   LL
03103        ADD   C.3
03104        STO   LL
03105 16A    LAC   LL,1
03106        CLA   YO
03107 17A    STO   XX-1,1
03110        CLA   THETA
03111 18A    STO   YY-1,1
03112 19A    CLA   LL
03113        SUB   C.10
03114        TNZ   21A
03115 20A    TRA   70A
03116 21A    NULL
03116 22A    AXT   22,4
03117        PXA   0,4
03120        LAC   JUMP,4
03121        TXL   80A,4,-3
03122        XEC   *,4
03123        TRA   79A
03124        TRA   70A
03125 23A    CLA   N
03126        SUB   C.9
03127        TZE   25A
03130 24A    TRA   29A
03131 25A    NULL
03131 26A    CLA   C.11
03132        FDP   F
03133        STQ   C2
03134        CLA   C.3
03135        STO   LL
03136 27A    CLA   RO
03137        STO   XX
03140        CLA   THETAO
03141        STO   YY
03142 28A    TRA   32A
03143 29A    CLA   N
03144        SUB   C.12
03145        TZE   31A
03146 30A    TRA   36A
03147 31A    NULL
03147 32A    TSX   .FWRD,,4
03150        TXI   *+4,,2
03151        PZE   32,,LK.DR
03152        PZE   .UN06.
03153        PZE   1007.
03154 33A    TSX   .FSLO.,4
03155        TXI   *+4,,2
03156        PZE   33,,LK.DR
03157        PZE   TITLE
03160        PZE   C.13
03161        TSX   .FFIL.,4
03162 34A    TSX   .FWRD.,4
03163        TXI   *+4,,2
03164        PZE   34,,LK.DR
03165        PZE   .UN06.
03166        PZE   1002.
03167        TSX   .FFIL.,4
03170 35A    CLA   C.3
03171        STO   N
03172 36A    LDQ   YO+5
03173        FMP   YO+5
03174        STO   N.
03175        LDQ   YO+4
03176        FMP   YO+4
03177        STO   N.+1
03200        LDQ   YO+3
03201        FMP   YO+3
03202        FAD   N.+1
03203        FAD   N.
03204        STO   YOSQP
03205 37A    CLA   YO+6
03206        FDP   C.14
03207        STQ   GRODEL
03210 38A    NULL
03210 39A    TSX   POLAR,4
03211        TXI   *+2,,0
03212        PZE   39,,LK.DR
03213 40A    LDQ   RARG
03214        FMP   C.4
03215        STO   RARG
03216 41A    CLA   NPOWER
03217        SUB   C.9
03220        TZE   43A
03221 42A    TRA   46A
03222 43A    NULL
03222 44A    STZ   PL
03223        STZ   DEL2S
03224 45A    TRA   49A
03225 46A    CLS   YO+10
03226        STO   X.1
03227 47A    TSX   EXP,4
03230        TXI   *+3,,1
03231        PZE   47,,LK.DR
03232        PZE   X.1
03233        STO   N.
03234        LDQ   FMU
03235        FMP   PROPT
03236        XCA
03237        FMP   N.
03240        STO   N.
03241 48A    TSX   ALOG10,4
03242        TXI   *+3,,1
03243        PZE   48,,LK.DR
03244        PZE   N.
03245        XCA
03246        FMP   C.15
03247        STO   PL
03250 49A    TSX   .FWRD.,4
03251        TXI   *+4,,2
03252        PZE   49,,LK.DP
03253        PZE   .UN06.
03254        PZE   1003.
03255        CLA   FINVP
03256        TSX   .FCNV.,4
03257        CLA   YO
03260        TSX   .FCNV.,4
03261        CLA   THETA
03262        TSX   .FCNV.,4
03263        CLA   PHI
03264        TSX   .FCNV.,4
03265        CLA   YO+8
03266        TSX   .FCNV.,4
03267        CLA   DSHIFT
03270        TSX   .FCNV.,4
03271        CLA   PL
03272        TSX   .FCNV.,4
03273        CLA   YO+6
03274        TSX   .FCNV.,4
03275        CLA   YO+3
03276        TSX   .FCNV.,4
03277        CLA   YO+4
03300        TSX   .FCNV.,4
03301        CLA   YO+5
03302        TSX   .FCNV.,4
03303        CLA   EMUS
03304        TSX   .FCNV.,4
03305        CLA   YOSQR
03306        TSX   .FCNV.,4
03307        CLA   EPSTIN
03310        TSX   .FCNV.,4
03311        CLA   YO+7
03312        TSX   .FCNV.,4
03313        CLA   RMOD
03314        TSX   .FCNV.,4
03315        CLA   RARG
03316        TSX   .FCNV.,4
03317        CLA   VALCRT
03320        TSX   .FCNV.,4
03321        CLA   EN
03322        TSX   .FCNV.,4
03323        CLA   GNU
03324        TSX   .FCNV.,4
03325        CLA   GRODEL
03326        TSX   .FCNV.,4
03327        TSX   .FFIL.,4
03330 50A    CLA   N
03331        ADD   C.3
03332        STO   N
03333 51A    AXT   51,4
03334        PXA   0,4
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03335 1757J LAC  **,4           03425       STO  JUMP           03512       AXT  **,4
03336       TXL  80A,4,-12      03426 64A   TRA  15A            03513       LDI  *+2
03337       XEC  *,4            03427 65A   TSX  .FWRD.,4       03514       TRA  1,4
03340       TRA  79A            03430       TXI  *+4,,2         03515       PZE  **
03341       TRA  52A            03431       PZE  65,,LK.DR      03516       STI  *-1
03342       TRA  54A            03432       PZE  .UN06.         03517       SXA  SYSLOC,4
03343       TRA  56A            03433       PZE  2046.          03520       SXA  LK.DR,4
03344       TRA  58A            03434       CLA  YD             03521       SXA  *-7,4
03345       TRA  60A            03435       TSX  .FCNV.,4       03522       SXA  *-9,1
03346       TRA  62A            03436       TSX  .FFIL.,4       03523       CLA  3,4
03347       TRA  79A            03437       CLA  THETA          03524       STA  9A
03350       TRA  65A            03440       FSB  C.16           03525       STA  1757J
03351       TRA  79A            03441       STO  N.             03526       TRA  1A
03352       TRA  79A            03442       CLA  N.
03353 52A   TSX  .FWRD.,4       03443       SSP
03354       TXI  *+4,,2         03444       SUB  C.17
03355       PZE  52,,LK.DR      03445       TZE  68A
03356       PZE  .UN06.         03446       TPL  68A
03357       PZE  2040.          03447 66A   NULL
03360       TSX  .FFIL.,4       03447 67A   TRA  15A
03361 53A   TRA  63A            03450 68A   CLA  NYD1
03362 54A   TSX  .FWRD.,4       03451       ADD  C.3
03363       TXI  *+4,,2         03452       STO  NYD1
03364       PZE  54,,LK.DR      03453 69A   TRA  15A
03365       PZE  .UN06.         03454 70A   CLA  NPLOT
03366       PZE  2041.          03455       SUB  C.9
03367       TSX  .FFIL.,4       03456       TNZ  72A
03370 55A   TRA  63A            03457 71A   TRA  OUTPUT+1
03371 56A   TSX  .FWRD.,4       03460 72A   NULL
03372       TXI  *+4,,2         03460 73A   TSX  CALC04,4
03373       PZE  56,,LK.DR      03461       TXI  *+5,,3
03374       PZE  .UN06.         03462       PZE  73,,LK.DR
03375       PZE  2042.          03463       PZE  LB
03376       TSX  .FFIL.,4       03464       PZE  DD
03377 57A   TRA  63A            03465       PZE  SOA
03400 58A   TSX  .FWRD.,4       03466 74A   NULL
03401       TXI  *+4,,2         03466 75A   TSX  CALC05,4
03402       PZE  58,,LK.DR      03467       TXI  *+5,,3
03403       PZE  .UN06.         03470       PZE  75,,LK.DR
03404       PZE  2043.          03471       PZE  LL
03405       TSX  .FFIL.,4       03472       PZE  XX
03406 59A   TRA  63A            03473       PZE  YY
03407 60A   TSX  .FWRD.,4       03474 76A   CLA  C.3
03410       TXI  *+4,,2         03475       STO  JUMP
03411       PZE  60,,LK.DR      03476 77A   STZ  LL
03412       PZE  .UN06.         03477 78A   STZ  LB
03413       PZE  2044.          03500 79A   TRA  OUTPUT+1
03414       TSX  .FFIL.,4       03501 80A   STA  *+3
03415 61A   TRA  63A            03502       TSX  .FXEM.,4
03416 62A   TSX  .FWRD.,4       03503       TXI  *+3,,1
03417       TXI  *+4,,2         03504       PZE  80,,LK.DR
03420       PZE  62,,LK.DR      03505       PZE  C.18
03421       PZE  .UN06.         03506 LK.DR PZE  **
03422       PZE  2045.          03507       BCI  1,OUTPU
03423       TSX  .FFIL.,4       03510 OUTPUT TXI *+6,,**
03424 63A   CLA  C.6            03511       AXT  **,1
```

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 03527.

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                                            BLOCK  DATA

                                    COMMON    VARIABLES

                COMMON BLOCK     GRAPH0          ORIGIN       00000          LENGTH       00005

  SYMBOL      LOCATION      TYPE         SYMBOL     LOCATION      TYPE       SYMBOL      LOCATION      TYPE
  XMAX0        00000         R           XMIN0       00001         R         YMAX0        00002         R
  YMIN0        00003         R           PLT         00004         R

                COMMON BLOCK     GRAPH1          ORIGIN       00005          LENGTH       00005
  XMAX1        00000         R           XMIN1       00001         R         YMAX1        00002         R
  YMIN1        00003         R           DATE        00004         R

                COMMON BLOCK     CONST           ORIGIN       00012          LENGTH       00007
  ORDER        00000         R           EUBAR       00001         R         ELBAR        00002         R
  YCLOW        00003         R           HMAXT       00004         R         HMINT        00005         R
  KD           00006         I
   THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00021.
```

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SCA                                        STORAGE  MAP        02/06/69                PAGE
                                    SUBROUTINE  PRAM

                                           ENTRY POINTS
   PRAM         SECTION     2

                                           SUBROUTINES CALLED
   SYSLOC       SECTION     3

                                      EFN   IFN   CORRESPONDENCE
EFN         IFN         LOCATION      EFN         IFN         LOCATION      EFN         IFN         LOCATION
  THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00073.
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SUBROUTINE CALCO4

COMMON VARIABLES

COMMON BLOCK GRAPH0 ORIGIN 00001 LENGTH 00023

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
XMAX0	00000	R	XMIN0	00001	R	YMAX0	00002	R
YMIN0	00003	R	PLT	00004	R			

COMMON BLOCK GRAPH1 ORIGIN 00024 LENGTH 00011

XMAX1	00000	R	XMIN1	00001	R	YMAX1	00002	R
YMIN1	00003	R	DATE	00004	R			

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
PLDAT	00035	R						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MODE	00605	I	LVAL	00606	I	KVAL	00607	I
JVAL	00610	I	AR	00611	R	IC	00612	I
PHI	00613	R						

ENTRY POINTS

CALCO4	SECTION	4	CALCO5	SECTION	5	CALCO1	SECTION	6
CALCO2	SECTION	7	CALCO3	SECTION	8			

SUBROUTINES CALLED

PRAM	SECTION	9	AXIS	SECTION	10	SYMBOL	SECTION	11
NUMBER	SECTION	12	LINE	SECTION	13	PLOT	SECTION	14
SIN	SECTION	15	COS	SECTION	16	PLOTS	SECTION	17
CC.1	SECTION	18	CC.2	SECTION	19	CC.3	SECTION	20
CC.4	SECTION	21	SYSLOC	SECTION	22			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
12	70A	01427	10	65A	01404	11	68A	01416
600	85A	01475	300	111A	01626			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 02137.

SUBROUTINE DENSE

COMMON VARIABLES

COMMON BLOCK RECT ORIGIN 00001 LENGTH 13565

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
DU	00000	R	SOA	05672	R	LB	13564	I

COMMON BLOCK DATA ORIGIN 13566 LENGTH 00054

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R

COMMON BLOCK HBANK1 ORIGIN 13642 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	YO	00007	R	YD	00022	R
SCR	00035	R						

COMMON BLOCK RBLK1 ORIGIN 14303 LENGTH 00005

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
STZM5	00000	R	HPRIME	00001	R	PKDELN	00002	R
AMBDL	00003	R	HU	00004	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RPERD	14310	R	RAD	14311	R	DISMAX	14312	R
R	14313	R	TH	14314	R	AMPDA	14315	R
SNLAM1	14316	R	SNLAM2	14317	R	SNLAM3	14320	R
SNTH1	14321	R	SNTH2	14322	R	SNTH3	14323	R
CSTH1	14324	R	TNTH1	14325	R	TNTH2	14326	R
STSL	14327	R	ZM1	14330	R	ZM2	14331	R
ZM3	14332	R	ZM4	14333	R	ZM5	14334	R
H	14335	R	DIFF	14336	R	TWO	14337	R
DTHETA	14340	R	THETA1	14341	R	TNTH11	14342	R
DIS	14343	R	W1	14344	R	T17	14345	R
ENF	14346	R	DENFDR	14347	R	ZX	14350	R
DZXDR	14351	R	ENXR	14352	R	FNX	14353	R
DENXDR	14354	R	DENXDT	14355	R	FACTOR	14356	R
PKFRAC	14357	R	FRACIN	14360	R	DFDN	14361	R
T31	14362	R	CYO2	14363	R	AY2	14364	R
COAM	14365	R	SIAMS	14366	R	SL	14367	R
ST	14370	R						

ENTRY POINTS

DENSE	SECTION	6

SUBROUTINES CALLED

SIN	SECTION	7	COS	SECTION	8	TAN	SECTION	9
SQRT	SECTION	10	EXP	SECTION	11	ALOG	SECTION	12
SYSLOC	SECTION	13						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
40	21A	15117	41	23A	15161	118	28A	15315
3	FORMAT	14437	12	46A	15452			

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 15471.

SUBROUTINE FIELD

COMMON VARIABLES

COMMON BLOCK EXFLD ORIGIN 00001 LENGTH 00006

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
D2CY1R	00000	R	D2SY1R	00001	R	D2CY2T	00002	R
D2SY2T	00003	R	D2CY3P	00004	R	D2SY3P	00005	R

COMMON BLOCK DATA ORIGIN 00007 LENGTH 00054

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	FMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHUR	00037	R	DFHDT	00040	R
DCPUT	00041	R	DCPUY1	00042	R	DCPDY2	00043	R
DCPUY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NTEST	00053	I			

COMMON BLOCK HBANK1 ORIGIN 00063 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK GAUSS ORIGIN 00524 LENGTH 00007

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
YSQUAR	00000	R	DCPUP	00001	R	DCPDP	00002	R
DFHUP	00003	R	F1T	00004	R	DNMNTR	00005	R
DEL2S	00006	R						

COMMON BLOCK CRSR ORIGIN 00533 LENGTH 00013

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
F2T	00546	R	RTF1T	00547	R	YO4S	00550	R
YO5C	00551	R	F1P	00552	R			

ENTRY POINTS

FIELD SECTION 7

FIEL STORAGE MAP

SUBROUTINES CALLED

SORT SECTION 8 SYSLOC SECTION 9

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
100	1A	00570	101	2A	00603	102	4A	00610
103	5A	00621	104	6A	00633	105	7A	00634
106	8A	00637	107	9A	00651	108	13A	00766

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 01021.

SUBROUTINE POWERL

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DEHDR	00037	R	DEHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEW	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I	YP	00007	R			

COMMON BLOCK POWLOS ORIGIN 00515 LENGTH 00023

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
COSA	00000	R	Y	00001	R	DMDR	00002	R
DMDT	00003	R	DMDP	00004	R	DMDY1	00005	R
DMDY2	00006	R	DMDY3	00007	R	DMDST	00010	R
DMDDSI	00011	R	DMUDR	00012	R	DMUDT	00013	R
DMUDP	00014	R	DMUDY1	00015	R	DMUDY2	00016	R
DMUDY3	00017	R	DMUDSI	00020	R	EMD	00021	R
EMRAD	00022	R						

COMMON BLOCK CRSR ORIGIN 00540 LENGTH 00013

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

COMMON BLOCK GAUSS ORIGIN 00553 LENGTH 00007

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
YSQUAR	00000	R	DCPDR	00001	R	DCPDP	00002	R
DFHDP	00003	R	FIT	00004	R	DNMNTR	00005	R
DEL2S	00006	R						

COMMON BLOCK EXFLD ORIGIN 00562 LENGTH 00006

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
D2CY1R	00000	R	D2SY1R	00001	R	D2CY2T	00002	R
D2SY2T	00003	R	D2CY3P	00004	R	D2SY3P	00005	R

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
A	00570	R	B	00601	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
Y2	00612	R	TERMC1	00613	R	COSPS2	00614	R
AA2	00615	R	YC	00616	R	AA2C1	00617	R
ENDA2C	00620	R	XTERM	00621	R	FMPAD2	00622	R
FHCSP2	00623	R	F2C	00624	R	TO	00625	R
PO	00626	R	SIPO	00627	R	COPO	00630	R
SITO	00631	R	COTO	00632	R	RO2	00633	R
COP	00634	R	SIP	00635	R	SIPMP	00636	R
COPMP	00637	R	RP2	00640	R	RP	00641	R
COTP	00642	R	SITP	00643	R	COPP	00644	R
DRPUR	00645	R	DRPDT	00646	R	DRPDP	00647	R
DRDRP	00650	R	DTDRP	00651	R	DPDRP	00652	R
D2MY1R	00653	R	D2MY2T	00654	R	D2MY3P	00655	R
D2AY1R	00656	R	D2AY2T	00657	R	D2AY3P	00660	R
DADY1	00661	R	DADY2	00662	R	DADY3	00663	R
DADR	00664	R	DADT	00665	R	DADP	00666	R
DBDR	00667	R	DBDT	00670	R	DBDP	00671	R
DBDSI	00672	R	D2MUSR	00673	R	D2MDST	00674	R
D2MDSP	00675	R	D2UDSR	00676	R	D2UDST	00677	R
D2UDSP	00700	R	D2UY1R	00701	R	D2UY2T	00702	R
D2UY3P	00703	R	YPEMDU	00704	R	YP2MDU	00705	R
YP3MDU	00706	R	XTEM2	00707	R	XTFM	00710	R
DMUDRP	00711	R	DUDSRP	00712	R	DUY1RP	00713	R
DUY2RP	00714	R	DUY3RP	00715	R	RDOTP	00716	R

ENTRY POINTS

POWERL SECTION 8

SUBROUTINES CALLED

SIN	SECTION	9	COS	SECTION	10	SQRT	SECTION	11
MINV	SECTION	12	SYSLOC	SECTION	13			

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
500	1A	00737	501	2A	01002	502	3A	01006
79	11A	01047	80	5A	01010	503	10A	01045
504	16A	01101	2	17A	01126	10	19A	01141
505	21A	01153	506	22A	01167	507	23A	01224
508	24A	01235	509	25A	01323	510	26A	01330
511	29A	01342	512	30A	01344	513	31A	01442
514	32A	01500	515	33A	01640	516	34A	01720
517	35A	02012	518	36A	02030	519	37A	02041
520	38A	02044	521	39A	02140	522	40A	02176
523	41A	02527	524	42A	02564	525	43A	02576

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526        44A       02603       527       46A       02650       528       47A       02653
529        48A       02671       530       49A       03010
THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 03032.
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SUBROUTINE FORCE

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00053

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THFTAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I						

COMMON BLOCK HBANK1 ORIGIN 00054 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
YNRMLZ	00515	R						

ENTRY POINTS

FORCE SECTION 4

SUBROUTINES CALLED

SYSLOC SECTION 5

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
100	1A	00522	101	2A	00525	102	3A	00533

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00553.

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         COL                         STORAGE  MAP          02/06/69                    PAGE
                                   SUBROUTINE  COLL

                                  DIMENSIONED PROGRAM VARIABLES

SYMBOL      LOCATION     TYPE        SYMBOL     LOCATION     TYPE        SYMBOL     LOCATION     TYPE
A           00001        R           B          00007        R           C          00015        R
D           00020        R

                                 UNDIMENSIONED PROGRAM VARIABLES

SYMBOL      LOCATION     TYPE        SYMBOL     LOCATION     TYPE        SYMBOL     LOCATION     TYPE
X           00023        R           COEFF      00024        R           XFAC       00025        R
S           00026        R           E          00027        R

                                         ENTRY POINTS

      COLL        SECTION     2

                                      SUBROUTINES CALLED

      .XP3.       SECTION     3          COS        SECTION      4          SIN        SECTION     5
      SYSLOC      SECTION     6

                                  EFN  IEN  CORRESPONDENCE

EFN         IEN         LOCATION     EFN        IEN        LOCATION      EFN        IEN        LOCATION
4           2A          00056        5          4A         00062         6          7A         00076
9           5A          00067        65         9A         00125         7          11A        00131
8           16A         00223        75         14A        00151         85         17A        00226

  THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00276.
```

SUBROUTINE CSINT

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
A0	00001	R	A2	00005	R	A4	00011	R
A6	00015	R	QP	00021	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
X	00025	R	M	00026	I	MM	00027	I
POEX	00030	R	QOEX	00031	R	POLD	00032	R
QOLD	00033	R	SGN	00034	R	ERROR	00035	R
N	00036	I	NN	00037	I	NNN	00040	I
BN	00041	R	CN	00042	R	P	00043	R
PP	00044	R	PPP	00045	R	Q	00046	R
AN	00047	R	TERM	00050	R	XSQ	00051	R
REC	00052	R	CC	00053	R	SS	00054	R

ENTRY POINTS

CSINT	SECTION	2

SUBROUTINES CALLED

TOR	SECTION	3	.XP3.	SECTION	4	COS	SECTION	5
SIN	SECTION	6	.FWRD.	SECTION	7	EXIT	SECTION	8
ALOG	SECTION	9	.UN06.	SECTION	10	.FFIL.	SECTION	11
.FCNV.	SECTION	12	E.1	SECTION	13	E.2	SECTION	14
E.3	SECTION	15	E.4	SECTION	16	CC.1	SECTION	17
CC.2	SECTION	18	CC.3	SECTION	19	CC.4	SECTION	20
SYSLOC	SECTION	21						

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
5	2A	00120	6	3A	00122	7	4A	00124
400	44A	00354	4	6A	00130	20	7A	00140
40	34A	00305	21	13A	00170	30	23A	00235
22	15A	00173	24	18A	00214	25	20A	00230
26	22A	00233	35	31A	00277	31	25A	00240
33	28A	00261	34	30A	00275	36	33A	00303
41	37A	00311	42	40A	00333	500	80A	00664
401	46A	00357	402	48A	00370	409	51A	00374
1000	FORMAT	00107	403	49A	00371	404	50A	00373
410	53A	00400	5002	84A	00672	411	54A	00420
55	56A	00444	420	57A	00446	440	77A	00662
421	61A	00467	430	68A	00564	422	63A	00472
425	67A	00562	424	65A	00556	435	75A	00657
431	70A	00567	434	74A	00655	433	72A	00651

CST STORAGE MAP 02/06/69 PAGE

501	82A	00667	503	83A	00671	5005	85A	00672
5006	86A	00700	5007	90A	00701	5008	98A	00716
5009	99A	00730	5010	102A	00742	5011	103A	00762

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 01024.

SUBROUTINE POLAR

COMMON VARIABLES

COMMON BLOCK DATA ORIGIN 00001 LENGTH 00054

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
RMAX	00000	R	RMIN	00001	R	TMAX	00002	R
TMIN	00003	R	PMAX	00004	R	PMIN	00005	R
PRNT	00006	R	RELERR	00007	R	AO	00010	R
BO	00011	R	RO	00012	R	THETAO	00013	R
PHIO	00014	R	PLUS	00015	R	NPOWER	00016	I
NPLOT	00017	I	J	00020	I	NUAR	00021	I
N1	00022	I	EN	00023	R	DNDR	00024	R
DNDT	00025	R	DNDP	00026	R	EMU	00027	R
RTYSQR	00030	R	F	00031	R	F2	00032	R
C1	00033	R	FH	00034	R	COSPSI	00035	R
SINPSI	00036	R	DFHDR	00037	R	DFHDT	00040	R
DCPDT	00041	R	DCPDY1	00042	R	DCPDY2	00043	R
DCPDY3	00044	R	SP2	00045	R	EMUINT	00046	R
EMUS	00047	R	N	00050	I	GNU	00051	R
MUFLAG	00052	I	NTEST	00053	I			

COMMON BLOCK HBANK1 ORIGIN 00055 LENGTH 00441

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
MORDER	00000	I	NOHALF	00001	I	NODOUB	00002	I
HBANK	00003	R	NOEQ	00004	I	FINVP	00005	R
FINVPI	00006	R	YO	00007	R	YD	00022	R
MA	00035	I						

COMMON BLOCK CRSR ORIGIN 00516 LENGTH 00013

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
C	00000	R	RCT	00001	R	S	00002	R
RST	00003	R	Z	00004	R	FM	00005	R
TERM	00006	R	TERM2	00007	R	RMOD	00010	R
RARG	00011	R	Y06	00012	R			

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
R	00531	C	XMZ	00533	C	Y	00535	R
YL	00536	R	YT	00537	R	YL2	00540	R
YT2	00541	R	YT4	00542	R			

ENTRY POINTS

POLAR SECTION 5

SUBROUTINES CALLED

CSQRT	SECTION 6	.CFDP.	SECTION 7	.CFMP.	SECTION 8
CABS	SECTION 9	ATAN2	SECTION 10	E.1	SECTION 11
E.2	SECTION 12	E.3	SECTION 13	E.4	SECTION 14
SYSLOC	SECTION 15				

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
101	2A	00616	102	4A	00717	103	6A	00724

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00753.

FUNCTION TOR TYPE R

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
F.0000	00001	R	X	00002	R	TEMP	00003	R
NOR	00004	I						

ENTRY POINTS

TOR	SECTION	2

SUBROUTINES CALLED

.XP1.	SECTION	3	EXP	SECTION	4	SQRT	SECTION	5
E.1	SECTION	6	E.2	SECTION	7	E.3	SECTION	8
E.4	SECTION	9	CC.1	SECTION	10	CC.2	SECTION	11
CC.3	SECTION	12	CC.4	SECTION	13	SYSLOC	SECTION	14

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00124.

SUBROUTINE MINV

DIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
IPIV	00001	I						

UNDIMENSIONED PROGRAM VARIABLES

SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE	SYMBOL	LOCATION	TYPE
I	00004	I	NMI	00005	I	IMAX	00006	I
IPI	00007	I	J	00010	I	IPJ	00011	I
IPMAX	00012	I	TEMP	00013	R	IPIVI	00014	I
IPN	00015	I	ICOMP	00016	I	IPCO	00017	I
ICOPI	00020	I						

ENTRY POINTS

MINV	SECTION	2

SUBROUTINES CALLED

E.1	SECTION	3	E.2	SECTION	4	E.3	SECTION	5
E.4	SECTION	6	CC.1	SECTION	7	CC.2	SECTION	8
CC.3	SECTION	9	CC.4	SECTION	10	SYSLOC	SECTION	11

EFN IFN CORRESPONDENCE

EFN	IFN	LOCATION	EFN	IFN	LOCATION	EFN	IFN	LOCATION
1	5A	00037	2	52A	00257	5	25A	00140
6	24A	00136	7	50A	00255	8	44A	00245
9	80A	00351	10	78A	00347	11	72A	00337
12	114A	00472	13	106A	00450	14	91A	00412
15	104A	00446	16	98A	00436	17	109A	00464
30	124A	00517						

THE FIRST LOCATION NOT USED BY THIS PROGRAM IS 00636.

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$IBLDR SMK2                                    02/17/69  SMK20000
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     ASSEMBLED TEXT.

          $TEXT  SMK2                                                                    SMK20001

                                    *7044 FORTRAN IV SET UP ROUTINE FOR JP-MARK                        SMK00010
                                    *          PROGRAMMER-R.GOODELL                                    SMK00020
                                    *          MAP-7044                                                SMK00040
                                    *     CALL SMARK(KIND,N,HBANK-3,NRTN,NTRG,EU,EL,HMX,HMN,YL,         SMK00050
                                    *     ETC  LV1,TV1,                                                SMK00060
                                    *     ETC  LV2,TV2,                                                SMK00070
                                    *     ETC  UP TP TEN TRIGGERS                                      SMK00080
                   00000                  ENTRY SMARK                                               SMK00090
                   00031            NOFIRG EQU 25                 NUMBER OF TRIGGERS
                   00000             SMARK SAVE 1,2,4                                              SMK00100

  BINARY CARD (NOT PUNCHED)
       00000  1 00000 0 00005  10001
       00001  0774 00 2 00000  10000
       00002  0774 00 1 00000  10000
       00003  0774 00 4 00000  10000
       00004  0020 00 4 00001  10000
       00005  0634 00 4 12000  10011
       00006  0634 00 4 00355  10001
       00007  0634 00 4 00003  10001
       00010  0634 00 1 00002  10001
       00011  0634 00 2 00001  10001
       00012  1 77776 4 01001  10011        TXI   *+1,4,-2                                      SMK00110
       00013  4500 60 4 00001  10000        CAL*  1,4                                           SMK00120
       00014  0767 00 0 00017  10000        ALS   15                                            SMK00130
       00015  4501 00 0 00351  10001        ORA   ADER         DER1,0,DER2                      SMK00140
       00016  0602 00 0 00102  10001        SLW   CMARK+2                                       SMK00150
       00017  0500 00 4 00003  10000        CLA   3,4                                           SMK00160
       00020  0400 00 0 00357  10001        ADD   =3                                            SMK00170
       00021  0621 00 0 00101  10001        STA   CMARK+1                                       SMK00180
       00022  0400 00 0 00360  10001        ADD   =1                                            SMK00190

  BINARY CARD (NOT PUNCHED)
       00023  0621 00 0 00033  10001        STA   STON                                          SMK00200
       00024  0400 00 0 00360  10001        ADD   =1                                            SMK00210
       00025  0621 00 0 00352  10001        STA   AINV                                          SMK00220
       00026  0400 00 0 00360  10001        ADD   =1                                            SMK00230
       00027  0621 00 0 01001  10011        STA   *+1                                           SMK00240
       00030  0600 00 0 00000  10000        STZ   **                                            SMK00250
       00031  0500 60 4 00002  10000        CLA*  2,4                                           SMK00260
       00032  0767 00 0 00022  10000        ALS   18                                            SMK00270
       00033  0622 00 0 00000  10000   STON STD   **                                            SMK00280
       00034  0500 00 4 00004  10000        CLA   4,4                                           SMK00290
       00035  0621 00 0 00353  10001        STA   NRTN                                          SMK00300
       00036  0500 00 4 00005  10000        CLA   5,4                                           SMK00310
       00037  0621 00 0 00354  10001        STA   NTRG                                          SMK00320
       00040  0500 60 4 00006  10000        CLA*  6,4                                           SMK00330
       00041  0601 00 0 13000  10011        STO   EUBAR                                         SMK00340
                                    *       EXTERN EUBAR                                        SMK00350
       00042  0500 60 4 00007  10000        CLA*  7,4                                           SMK00360
       00043  0601 00 0 14000  10011        STO   ELBAR                                         SMK00370
                                    *       EXTERN ELBAR                                        SMK00380
       00044  0500 60 4 00010  10000        CLA*  8,4                                           SMK00390
       00045  0601 00 0 15000  10011        STO   HMAXT                                         SMK00400
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                                             *        EXTERN  HMAXT                                   SMK00410
BINARY CARD (NOT PUNCHED)
        00046  0500 60 4 00011  10000                 CLA*    9,4                                     SMK00420
        00047  0601 00 0 16000  10011                 STO     HMINT                                   SMK00430
                                             *        EXTERN  HMINT                                   SMK00440
        00050  0500 60 4 00012  10000                 CLA*    10,4                                    SMK00450
        00051  0601 00 0 17000  10011                 STO     YCLOW                                   SMK00460
                                             *        EXTERN  YCLOW                                   SMK00470
        00052  0600 00 0 20000  10011                 STZ     RGERR                                   SMK00480
                                             *        EXTERN  RGERR                                   SMK00490
        00053  0774 00 1 00000  10000                 AXT     0,1                                     SMK00500
        00054  0500 00 4 00013  10000        STRG     CLA     11,4                                    SMK00510
        00055  4320 00 0 00361  10001                 ANA     =0777777000000                          SMK00520
        00056  4100 00 0 00072  10001                 TNZ     ENTRG                                   SMK00530
        00057  0500 00 4 00013  10000                 CLA     11,4                                    SMK00540
        00060  0340 00 0 00352  10001                 CAS     AINV            INDEPENDENT VARIABLE    SMK00550
        00061  0020 00 0 01002  10011                 TRA     *+2                                     SMK00560
        00062  0500 00 0 00362  10001                 CLA     =0                                      SMK00570
        00063  0767 00 0 00022  10000                 ALS     18                                      SMK00580
        00064  0622 00 1 00104  10001                 STD     TRG,1                                   SMK00590
        00065  0500 00 4 00014  10000                 CLA     12,4                                    SMK00630
        00066  0621 00 1 00105  10001                 STA     TRG+1,1                                 SMK00640
        00067  1 77776 1 01001  10011                 TXI     *+1,1,-2                                SMK00650
        00070  7 77716 1 00100  10001                 TXL     CMARK,1,-2*NOFTRG
BINARY CARD (NOT PUNCHED)
        00071  1 77776 4 00054  10001                 TXI     STRG,4,-2                               SMK00670
        00072  0500 00 1 00104  10001        ENTRG    CLA     TRG,1           TURN OFF REMAINING TRIGGERS  SMK00680
        00073  0760 00 0 00003  10000                 SSP                                             SMK00690
        00074  0760 00 0 00002  10000                 CHS                                             SMK00700
        00075  0601 00 1 00104  10001                 STO     TRG,1                                   SMK00710
        00076  1 77776 1 01001  10011                 TXI     *+1,1,-2                                SMK00720
        00077  3 77716 1 00072  10001                 TXH     ENTRG,1,-2*NOFTRG
        00100  0074 00 4 21000  10011        CMARK    TSX     MARK,4                                  SMK00740
                                             *        EXTERN  MARK                                    SMK00750
        00101  0 00167 0 00000  10100                 PZE     **,0,FOS                                SMK00760
        00102  0 00173 0 00171  10101                 PZE     DER1,,DER2                              SMK00770
        00103  0020 00 0 00344  10001                 TRA     EMARK                                   SMK00780
        00104  0 00000 0 00260  10001        TRG      PZE     TRG1                                    SMK00790
        00105  0 00000 0 00000  10000                 PZE                                             SMK00800
        00106  0 00000 0 00262  10001                 PZE     TRG2                                    SMK00810
        00107  0 00000 0 00000  10000                 PZE                                             SMK00820
        00110  0 00000 0 00264  10001                 PZE     TRG3                                    SMK00830
        00111  0 00000 0 00000  10000                 PZE                                             SMK00840
        00112  0 00000 0 00266  10001                 PZE     TRG4                                    SMK00850
        00113  0 00000 0 00000  10000                 PZE                                             SMK00860
BINARY CARD (NOT PUNCHED)
        00114  0 00000 0 00270  10001                 PZE     TRG5                                    SMK00870
        00115  0 00000 0 00000  10000                 PZE                                             SMK00880
        00116  0 00000 0 00272  10001                 PZE     TRG6                                    SMK00890
        00117  0 00000 0 00000  10000                 PZE                                             SMK00900
        00120  0 00000 0 00274  10001                 PZE     TRG7                                    SMK00910
        00121  0 00000 0 00000  10000                 PZE                                             SMK00920
        00122  0 00000 0 00276  10001                 PZE     TRG8                                    SMK00930
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ASSEMBLED TEXT.

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        00123  0 00000 0 00000  10000          PZE                SMK00940
        00124  0 00000 0 00300  10001          PZE     TRG9       SMK00950
        00125  0 00000 0 00000  10000          PZE                SMK00960
        00126  0 00000 0 00302  10001          PZE     TRG10      SMK00970
        00127  0 00000 0 00000  10000          PZE                SMK00980
        00130  0 00000 0 00304  10001          PZE     TRG11
        00131  0 00000 0 00000  10000          PZE
        00132  0 00000 0 00306  10001          PZE     TRG12
        00133  0 00000 0 00000  10000          PZE
        00134  0 00000 0 00310  10001          PZE     TRG13
        00135  0 00000 0 00000  10000          PZE
        00136  0 00000 0 00312  10001          PZE     TRG14

BINARY CARD (NOT PUNCHED)
        00137  0 00000 0 00000  10000          PZE
        00140  0 00000 0 00314  10001          PZE     TRG15
        00141  0 00000 0 00000  10000          PZE
        00142  0 00000 0 00316  10001          PZE     TRG16
        00143  0 00000 0 00000  10000          PZE
        00144  0 00000 0 00320  10001          PZE     TRG17
        00145  0 00000 0 00000  10000          PZE
        00146  0 00000 0 00322  10001          PZE     TRG18
        00147  0 00000 0 00000  10000          PZE
        00150  0 00000 0 00324  10001          PZE     TRG19
        00151  0 00000 0 00000  10000          PZE
        00152  0 00000 0 00326  10001          PZE     TRG20
        00153  0 00000 0 00000  10000          PZE
        00154  0 00000 0 00330  10001          PZE     TRG21
        00155  0 00000 0 00000  10000          PZE
        00156  0 00000 0 00332  10001          PZE     TRG22
        00157  0 00000 0 00000  10000          PZE
        00160  0 00000 0 00334  10001          PZE     TRG23
        00161  0 00000 0 00000  10000          PZE

BINARY CARD (NOT PUNCHED)
        00162  0 00000 0 00336  10001          PZE     TRG24
        00163  0 00000 0 00000  10000          PZE
        00164  0 00000 0 00340  10001          PZE     TRG25
        00165  0 00000 0 00000  10000          PZE
        00166  0 00000 0 00000  10000          PZE                SMK00990
        00167  0500 00 0 00360  10001   EOS    CLA     =1         SMK01000
        00170  0020 00 0 00176  10001          TRA     EXIT       SMK01010
        00171  0500 00 0 00363  10001   DER1   CLA     =2         SMK01020
        00172  0020 00 0 00176  10001          TRA     EXIT       SMK01030
        00173  0500 00 0 00357  10001   DER2   CLA     =3         SMK01040
        00174  0020 00 0 00176  10001          TRA     EXIT       SMK01050
        00175  0500 00 0 00364  10001   GTRG   CLA     =4         SMK01060
        00176  0634 00 4 00350  10001   EXIT   SXA     IX4,4      SMK01070
        00177  0634 00 1 00346  10001          SXA     IX1,1      SMK01080
        00200  0634 00 2 00347  10001          SXA     IX2,2      SMK01090
        00201  0601 60 0 00353  10001          STO*    NRTN       SMK01100
                         00202                 RETURN  SMARK      SMK01110
        00203  0774 00 0 00000  10000   TRA14  AXT     0,0        SMK01120
        00204  0534 00 4 00350  10001          LXA     IX4,4      SMK01130

BINARY CARD (NOT PUNCHED)
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     SMK2                                                    02/17/69                 PAGE
   ASSEMBLED TEXT.

     00205  0534 00 1 00346  10001          LXA    IX1,1                              SMK01140
     00206  0534 00 2 00347  10001          LXA    IX2,2                              SMK01150
     00207  0020 00 4 00001  10000          TRA    1,4                                SMK01160
                      00203                 ENTRY  TRA14                              SMK01170
     00210  0774 00 0 00000  10000   TRA24  AXT    0,0                                SMK01180
     00211  0534 00 4 00350  10001          LXA    IX4,4                              SMK01190
     00212  0534 00 1 00346  10001          LXA    IX1,1                              SMK01191
     00213  0534 00 2 00347  10001          LXA    IX2,2                              SMK01192
     00214  0020 00 4 00002  10000          TRA    2,4                                SMK01200
                      00210                 ENTRY  TRA24                              SMK01210
                                     *      CALL   ON(NOTRG)                          SMK01220
                      00215                 ENTRY  ON                                 SMK01230
                      00215          ON     SAVE   1,2,4                              SMK01240
     00215  1 00000 0 00222  10001
     00216  0774 00 2 00000  10000
     00217  0774 00 1 00000  10000
     00220  0774 00 4 00000  10000
     00221  0020 00 4 00001  10000
     00222  0634 00 4 12000  10011
     00223  0634 00 4 00355  10001
     00224  0634 00 4 00220  10001
     00225  0634 00 1 00217  10001
     00226  0634 00 2 00216  10001
     00227  0500 60 4 00003  10000          CLA*   3,4                                SMK01250

BINARY CARD (NOT PUNCHED)
     00230  0767 00 0 00001  10000          ALS    1                                  SMK01260
     00231  0737 00 1 00000  10000          PAC    **,1                               SMK01270
     00232  0500 00 1 00102  10001          CLA    TRG-2,1                            SMK01280
     00233  0760 00 0 00003  10000          SSP                                       SMK01290
     00234  0601 00 1 00102  10001          STO    TRG-2,1                            SMK01300
                      00235                 RETURN ON                                 SMK01310
                                     *      CALL   OFF(NOTRG)                         SMK01320
                      00236                 ENTRY  OFF                                SMK01330
                      00236          OFF    SAVE   1,2,4                              SMK01340
     00236  1 00000 0 00243  10001
     00237  0774 00 2 00000  10000
     00240  0774 00 1 00000  10000
     00241  0774 00 4 00000  10000
     00242  0020 00 4 00001  10000
     00243  0634 00 4 12000  10011
     00244  0634 00 4 00355  10001
     00245  0634 00 4 00241  10001
     00246  0634 00 1 00240  10001
     00247  0634 00 2 00237  10001
     00250  0500 60 4 00003  10000          CLA*   3,4                                SMK01350
     00251  0767 00 0 00001  10000          ALS    1                                  SMK01360
     00252  0737 00 1 00000  10000          PAC    **,1                               SMK01370

BINARY CARD (NOT PUNCHED)
     00253  0500 00 1 00102  10001          CLA    TRG-2,1                            SMK01380
     00254  0760 00 0 00003  10000          SSP                                       SMK01390
     00255  0760 00 0 00002  10000          CHS                                       SMK01400
     00256  0601 00 1 00102  10001          STO    TRG-2,1                            SMK01410
                      00257                 RETURN OFF                                SMK01420
     00260  0500 00 0 00360  10001   TRG1   CLA    =1                                 SMK01430
```

```
      00261  0020 00 0 00341  10001           TRA    ETRG
      00262  0500 00 0 00363  10001   TRG2    CLA    =2                SMK01440
      00263  0020 00 0 00341  10001           TRA    ETRG              SMK01450
      00264  0500 00 0 00357  10001   TRG3    CLA    =3                SMK01460
      00265  0020 00 0 00341  10001           TRA    ETRG              SMK01470
      00266  0500 00 0 00364  10001   TRG4    CLA    =4                SMK01480
      00267  0020 00 0 00341  10001           TRA    ETRG              SMK01490
      00270  0500 00 0 00365  10001   TRG5    CLA    =5                SMK01500
      00271  0020 00 0 00341  10001           TRA    ETRG              SMK01510
      00272  0500 00 0 00366  10001   TRG6    CLA    =6                SMK01520
      00273  0020 00 0 00341  10001           TRA    ETRG              SMK01530
      00274  0500 00 0 00367  10001   TRG7    CLA    =7                SMK01540
      00275  0020 00 0 00341  10001           TRA    ETRG              SMK01550
                                                                       SMK01560
BINARY CARD (NOT PUNCHED)
      00276  0500 00 0 00370  10001   TRG8    CLA    =8                SMK01570
      00277  0020 00 0 00341  10001           TRA    ETRG              SMK01580
      00300  0500 00 0 00371  10001   TRG9    CLA    =9                SMK01590
      00301  0020 00 0 00341  10001           TRA    ETRG              SMK01600
      00302  0500 00 0 00372  10001   TRG10   CLA    =10               SMK01610
      00303  0020 00 0 00341  10001           TRA    ETRG
      00304  0500 00 0 00373  10001   TRG11   CLA    =11
      00305  0020 00 0 00341  10001           TRA    ETRG
      00306  0500 00 0 00374  10001   TRG12   CLA    =12
      00307  0020 00 0 00341  10001           TRA    ETRG
      00310  0500 00 0 00375  10001   TRG13   CLA    =13
      00311  0020 00 0 00341  10001           TRA    ETRG
      00312  0500 00 0 00376  10001   TRG14   CLA    =14
      00313  0020 00 0 00341  10001           TRA    ETRG
      00314  0500 00 0 00377  10001   TRG15   CLA    =15
      00315  0020 00 0 00341  10001           TRA    ETRG
      00316  0500 00 0 00400  10001   TRG16   CLA    =16
      00317  0020 00 0 00341  10001           TRA    ETRG
      00320  0500 00 0 00401  10001   TRG17   CLA    =17

BINARY CARD (NOT PUNCHED)
      00321  0020 00 0 00341  10001           TRA    ETRG
      00322  0500 00 0 00402  10001   TRG18   CLA    =18
      00323  0020 00 0 00341  10001           TRA    ETRG
      00324  0500 00 0 00403  10001   TRG19   CLA    =19
      00325  0020 00 0 00341  10001           TRA    ETRG
      00326  0500 00 0 00404  10001   TRG20   CLA    =20
      00327  0020 00 0 00341  10001           TRA    ETRG
      00330  0500 00 0 00405  10001   TRG21   CLA    =21
      00331  0020 00 0 00341  10001           TRA    ETRG
      00332  0500 00 0 00406  10001   TRG22   CLA    =22
      00333  0020 00 0 00341  10001           TRA    ETRG
      00334  0500 00 0 00407  10001   TRG23   CLA    =23
      00335  0020 00 0 00341  10001           TRA    ETRG
      00336  0500 00 0 00410  10001   TRG24   CLA    =24
      00337  0020 00 0 00341  10001           TRA    ETRG
      00340  0500 00 0 00411  10001   TRG25   CLA    =25
      00341  0601 60 0 00354  10001   ETRG    STO*   NTRG              SMK01620
      00342  0500 00 0 00364  10001           CLA    =4                SMK01630
      00343  0020 00 0 00176  10001           TRA    EXIT              SMK01640
```

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      ASSEMBLED TEXT.

BINARY CARD (NOT PUNCHED)
        00344  0500 00 0 00365  10001  EMARK CLA   =5                       SMK01650
        00345  0020 00 0 00176  10001        TRA   EXIT                     SMK01660
        00346  0 00000 0 00000  10000  IX1   PZE                            SMK01670
        00347  0 00000 0 00000  10000  IX2   PZE                            SMK01680
        00350  0 00000 0 00000  10000  IX4   PZE                            SMK01690
        00351  0 00173 0 00171  10101  ADER  PZE   DER1,0,DER2              SMK01700
        00352  0 00000 0 00000  10000  AINV  PZE                            SMK01710
        00353  0 00000 0 00000  10000  NRIN  PZE                            SMK01720
        00354  0 00000 0 00000  10000  NTRG  PZE                            SMK01730
        00355  000000000000     10000        *LDIR
        00356  624442026060     10000
        00357  000000000003     10000        *LORG
        00360  000000000001     10000
        00361  777777000000     10000
        00362  000000000000     10000
        00363  000000000002     10000
        00364  000000000004     10000
        00365  000000000005     10000
        00366  000000000006     10000

BINARY CARD (NOT PUNCHED)
        00367  000000000007     10000
        00370  000000000010     10000
        00371  000000000011     10000
        00372  000000000012     10000
        00373  000000000013     10000
        00374  000000000014     10000
        00375  000000000015     10000
        00376  000000000016     10000
        00377  000000000017     10000
        00400  000000000020     10000
        00401  000000000021     10000
        00402  000000000022     10000
        00403  000000000023     10000
        00404  000000000024     10000
        00405  000000000025     10000
        00406  000000000026     10000
        00407  000000000027     10000
        00410  000000000030     10000
        00411  000000000031     10000

BINARY CARD (NOT PUNCHED)
                        00000  01111        END                            SMK01740
```

```
CONTROL DICTIONARY

        $CDICT SMK2                                                    SMK20002

  BINARY CARD (NOT PUNCHED)
        000412000000          PREFACE   START=0,LENGTH=266,TYPE=7094,CMPLX=5
        000004000005
        624442026060  SMK2    DECK
        000412000000
        624421514260  SMARK   REAL      SECT. 2,LOC=0,LENGTH=0
        000000000000
        624421514260  SMARK   REAL      SECT. 3,LOC=0,LENGTH=0
        000000000000
        635121010460  TRA14   REAL      SECT. 4,LOC=203,LENGTH=0
        000000000203
        635121020460  TRA24   REAL      SECT. 5,LOC=210,LENGTH=0
        000000000210
        464560606060  ON      REAL      SECT. 6,LOC=215,LENGTH=0
        000000000215
        464560606060  ON      REAL      SECT. 7,LOC=215,LENGTH=0
        000000000215
        462626606060  OFF     REAL      SECT. 8,LOC=236,LENGTH=0
        000000000236
        462626606060  OFF     REAL      SECT. 9,LOC=236,LENGTH=0
        000000000236
        627062434623  SYSLOC  VIRTUAL   SECT. 10
        200000000000

  BINARY CARD (NOT PUNCHED)
        256422215160  EUBAR   VIRTUAL   SECT. 11
        200000000000
        254322215160  ELBAR   VIRTUAL   SECT. 12
        200000000000
        304421676360  HMAXT   VIRTUAL   SECT. 13
        200000000000
        304431456360  HMINT   VIRTUAL   SECT. 14
        200000000000
        702343466660  YCLOW   VIRTUAL   SECT. 15
        200000000000
        512725515160  RGERR   VIRTUAL   SECT. 16
        200000000000
        442151426060  MARK    VIRTUAL   SECT. 17
        200000000000

        $DKEND SMK2                                                    SMK20003

  NO MESSAGES FOR THIS ASSEMBLY
```

REFERENCES TO DEFINED SYMBOLS.

```
CLASS  SYMBOL   VALUE   REFERENCES

       ADER     00351   15
       AINV     00352   25,60
       CMARK    00100   16,21,70
       DER1     00171   102,351
       DER2     00173   102,351
       EMARK    00344   103
       ENTRG    00072   56,77
       EOS      00167   101
       ETRG     00341   261,263,265,267,271,273,275,277,301,303,305,307,311,313,315,317,321,323,325,327,331,333,335,
                        337
       EXIT     00176   170,172,174,343,345
       GTRG     00175
       IX1      00346   177,205,212
       IX2      00347   200,206,213
       IX4      00350   176,204,211
       ..0001   00003   7,10,11
       ..0002   00004
       ..0003   00005   0
       ..0004   00220   224,225,226
       ..0005   00221
       ..0006   00222   215
       ..0007   00241   245,246,247
       ..0008   00242
       ..0009   00243   236
       NOFTRG   00031   70,77
       NRTN     00353   35,201
       NTRG     00354   37,341
       OFF      00236   236,236,257
       ON       00215   215,215,235
LCTR    BLCTR
QUAL    UNQS
LCTR   //
       SMARK    00000   0,0,202
       STON     00033   23
       STRG     00054   71
       TRA14    00203   210
       TRA24    00210   215
       TRG10    00302   126
       TRG11    00304   130
       TRG12    00306   132
       TRG13    00310   134
       TRG14    00312   136
       TRG15    00314   140
       TRG16    00316   142
       TRG17    00320   144
       TRG18    00322   146
       TRG19    00324   150
       TPG1     00260   104
       TRG20    00326   152
       TRG21    00330   154
       TRG22    00332   156
```

SYMBOL REFERENCE DATA

TRG23	00334	160
TRG24	00336	162
TRG25	00340	164
TRG2	00262	106
TRG3	00264	110
TRG4	00266	112
TRG5	00270	114
TRG6	00272	116
TRG7	00274	120
TRG8	00276	122
TRG9	00300	124
TRG	00104	64,66,72,75,232,234,253,256

REFERENCES TO VIRTUAL SYMBOLS.

ELBAR	12	43
EUBAR	11	41
HMAXT	13	45
HMINI	14	47
MARK	17	100
RGERR	16	52
SYSLOC	10	5,222,243
YCLOW	15	51

```
$IBLDR MARS                                   02/17/69    MARS0000
```

```
               $TEXT  MARS                                                                  MARS0001
                                   *      MARK      RUNGE-KUTTA,ADAMS-MOULTON INTEGRATOR PACKAGE        MARK0001
                                   *      CALLING SEQUENCE                                              MARK0002
                                   *      CALL      MARK                                                MARK0003
                                   *      PZE       HBANK,P,EOS                                         MARK0004
                                   *      PZE       DER1,PHI,DER2                                       MARK0005
                                   *      ERROR RETURN                                                  MARK0006
                                   *      PZE,MZE BJ,,YJ                                                MARK0007
                                   *      PZE       2J                                                  MARK0008
                                   *      PZE       0                                                   MARK0009
                                   *      MARK,HC,NI                                                    MARK0014
                      00000               ENTRY     MARK                                                MARK0015
                      00165               ENTRY     HC                                                  MARK0016
                      00166               ENTRY     NI                                                  MARK0017
                      00173        TGLO   ENTRY     TGO
                      00223               ENTRY     Y                                                   MARK0019
                      00224               ENTRY     YDOT                                                MARK0020
                      00225        Y121   ENTRY     Y(2)
                      00226               ENTRY     YO                                                  MARK0022
                      00227        Y0121  ENTRY     YO(2)
                      00326               ENTRY     EUBAR                                               MARK0024
                      00327               ENTRY     ELBAR                                               MARK0025
                      00330               ENTRY     HMAXT                                               MARK0026
                      00331               ENTRY     HMINT                                               MARK0027
                      00332               ENTRY     YCLOW                                               MARK0028
                      01671               ENTRY     RGERR                                               MARK0029
                      00062         OMAR  SET       50
BINARY CARD (NOT PUNCHED)
      00000  0634 00 4 00231  10001  MARK SXA       I4,4                                                MARK0030
      00001  0534 00 4 00231  10001 RSIRT LXA       I4,4                                                MARK0031
      00002  0634 00 4 00216  10001       SXA       AEOS,4                                              MARK0032
      00003  0534 00 1 00231  10001       LXA       I4,1                                                MARK0033
      00004  0500 00 1 00004  10000       CLA       4,1                                                 MARK0034
      00005  0100 00 0 00406  10011       TZE       *+6                                                 MARK0035
      00006  4734 00 2 00000  10000       PDX       0,2                                                 MARK0036
      00007  7 00000 2 00403  10011       TXL       *+3,2,0                                             MARK0037
      00010  0500 00 0 00400  10011       CLA       *                                                   MARK0038
      00011  0625 00 1 00004  10000       STT       4,1                                                 MARK0039
      00012  1 77776 1 40406  10011       TXI       *-6,1,-2                                            MARK0040
      00013  0500 00 4 00001  10000       CLA       1,4                                                 MARK0041
      00014  0625 00 0 00245  10001       STT       P                                                   MARK0042
      00015  0734 00 1 00400  10011       PAX       *,1                                                 MARK0043
      00016  1 77775 1 00401  10011       TXI       *+1,1,-3                                            MARK0044
      00017  0634 00 1 00242  10001       SXA       L(M),1                                              MARK0045
      00020  1 00005 1 00401  10011       TXI       *+1,1,5                                             MARK0046
      00021  0634 00 1 00243  10001       SXA       L(T1),1                                             MARK0047
      00022  1 00001 1 00401  10011       TXI       *+1,1,1                                             MARK0048
BINARY CARD (NOT PUNCHED)
      00023  0634 00 1 00244  10001       SXA       L(T2),1                                             MARK0049
      00024  0774 00 1 00000  10000       AXT       0,1              STORE USER H BANK                  MARK0050
      00025  0500 60 0 00242  10001       CLA*      L(M)             IN MARK COMMUNC AREA               MARK0051
      00026  0601 00 1 00232  10001       STO       M,1                                                 MARK0052
      00027  1 77777 1 00401  10011       TXI       *+1,1,-1                                            MARK0053
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      00030  3 77774 1 40403  10011      TXH    *-3,1,-4                            MARK0054
      00031  0500 60 0 00242  10001      CLA*   L(M)                                MARK0055
      00032  0621 00 0 00236  10001      STA    N                                   MARK0056
      00033  0771 00 0 00022  10000      ARS    18                                  MARK0057
      00034  0621 00 0 00237  10001      STA    (N)                                 MARK0058
      00035  0500 60 0 00243  10001      CLA*   L(T1)                               MARK0059
      00036  0601 00 0 00240  10001      STO    T1                                  MARK0060
      00037  0500 60 0 00244  10001      CLA*   L(T2)                               MARK0061
      00040  0601 00 0 00241  10001      STO    T2                                  MARK0062
      00041  0534 00 4 00231  10001      LXA    I4,4                                MARK0063
      00042  0500 00 4 00002  10000      CLA    2,4                                 MARK0064
      00043  0621 00 0 00250  10001      STA    DER1                                MARK0065
      00044  0765 00 0 00022  10000      LRS    18                                  MARK0066
      00045  0621 00 0 00247  10001      STA    DER2                                MARK0067

BINARY CARD (NOT PUNCHED)
      00046  4754 00 0 00000  10000      PXD    0,0
      00047  0131 00 0 00000  10000      XCA                  PHI TEST              MARK0069
      00050  0771 00 0 00040  10000      ARS    32                                  MARK0070
      00051  0601 00 0 00246  10001      STO    PHI                                 MARK0071
      00052  0734 00 1 00400  10011      PAX    *,1                                 MARK0072
      00053  0600 00 0 00251  10001      STZ    E
      00054  0020 00 1 00405  10011      TRA    *+5,1                               MARK0073
      00055  0771 00 0 00002  10000      ARS    2            PHI=4 - AM WITH AEC    MARK0074
      00056  0020 00 0 00403  10011      TRA    *+3                                 MARK0075
      00057  0760 00 0 00006  10000      COM                  PHI=2 - NO AM         MARK0076
      00060  0020 00 0 00406  10011      TRA    *+6                                 MARK0077
      00061  0601 00 0 00251  10001      STO    E            PHI=0 - AM NO AEC      MARK0078
      00062  0500 00 0 00254  10001      CLA    LSTRT                               MARK0079
      00063  0621 00 0 00214  10001      STA    TRIG0                               MARK0080
      00064  0500 60 0 00243  10001      CLA*   L(T1)                               MARK0081
      00065  0560 60 0 00244  10001      LDQ*   L(T2)                               MARK0082
      00066  0601 00 0 00221  10001      STO    TRG2                                MARK0083
      00067  4600 00 0 00222  10001      STQ    TRG2+1                              MARK0084
      00070  0500 00 0 00235  10001      CLA    H                                   MARK0085

BINARY CARD (NOT PUNCHED)
      00071  0601 00 0 01400  10011      STO    HC                                  MARK0086
      00072  0600 00 0 00167  10001      STZ    J            INITIALIZE J COUNT     MARK0087
      00073  0074 00 4 00334  10001      TSX    ADDR,4                              MARK0088
      00074  0534 00 1 00251  10001      LXA    E,1                                 MARK0089
      00075  1 00003 1 00401  10011      TXI    *+1,1,3                             MARK0090
      00076  0754 00 1 00000  10000      PXA    0,1          FORM BSS LENGTH        MARK0091
      00077  0400 00 0 00232  10001      ADD    M                                   MARK0092
      00100  0131 00 0 00000  10000      XCA                                        MARK0093
      00101  0200 00 0 00236  10001      MPY    N                                   MARK0094
      00102  4600 00 0 00202  10001      STQ    TEMP                                MARK0095
      00103  0131 00 0 00000  10000      XCA                                        MARK0096
      00104  0400 00 0 00202  10001      ADD    TEMP                                MARK0097
      00105  0601 00 0 00202  10001      STO    TEMP                                MARK0098
      00106  0560 00 0 00236  10001      LDQ    N                                   MARK0099
      00107  0200 00 0 00251  10001      MPY    E                                   MARK0100
      00110  0131 00 0 00000  10000      XCA                                        MARK0101
      00111  0400 00 0 00202  10001      ADD    TEMP                                MARK0102
      00112  4520 00 0 00251  10001      NZT    E                                   MARK0103
      00113  0020 00 0 00403  10011      TRA    *+3                                 MARK0104
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ASSEMBLED TEXT.

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BINARY CARD (NOT PUNCHED)
   00114  0400 00 0 00236  10001       ADD    N                                    MARK0105
   00115  0400 00 0 00236  10001       ADD    N                                    MARK0106
   00116  0734 00 2 00000  10000       PAX    0,2                                  MARK0107
   00117  0535 00 1 03400  10011       LAC    YDOT,1       CLEAR USER BSS AREA     MARK0108
   00120  0600 00 1 00000  10000       STZ    0,1                                  MARK0109
   00121  1 77777 1 00401  10011       TXI    *+1,1,-1                             MARK0110
   00122  2 00001 2 40402  10011       TIX    *-2,2,1                              MARK0111
   00123  0774 00 1 77777  10000       AXT    -1,1         INITIALIZE NH AND ND    MARK0112
   00124  0600 00 0 00233  10001       STZ    NH           IN MARK AND USER BANK   MARK0113
   00125  0600 00 0 00234  10001       STZ    ND                                   MARK0114
   00126  0600 00 0 00252  10001       STZ    HD                                   MARK0115
   00127  0500 60 0 00242  10001       CLA*   L(M)                                 MARK0116
   00130  0767 00 0 00022  10000       ALS    18                                   MARK0117
   00131  0622 60 0 00242  10001       STD*   L(M)                                 MARK0118
   00132  1 77777 1 00401  10011       TXI    *+1,1,-1                             MARK0119
   00133  0500 60 0 00242  10001       CLA*   L(M)                                 MARK0120
   00134  0767 00 0 00022  10000       ALS    18                                   MARK0121
   00135  0622 60 0 00242  10001       STD*   L(M)                                 MARK0122
   00136  4520 00 0 00251  10001       NZT    E                                    MARK0123

BINARY CARD (NOT PUNCHED)
   00137  0020 00 0 00405  10011       TRA    *+5                                  MARK0124
   00140  0500 00 0 00333  10001       CLA    RGFRK                                MARK0125
   00141  0601 00 0 00751  10001       STO    GT2                                  MARK0126
   00142  0600 00 0 01676  10001       STZ    A       STET FLAG WORD =0 FOR 2.0X (AEC)  MARK0127
   00143  0020 00 0 00403  10011       TRA    *+3                                  MARK0128
   00144  0500 00 0 01252  10001       CLA    ADAMS+2                              MARK0129
   00145  0601 00 0 00751  10001       STO    GT2                                  MARK0130
   00146  0522 00 0 00250  10001       XEC    DER1                                 MARK0131
   00147  0500 00 0 00240  10001       CLA    T1                                   MARK0132
   00150  0760 00 0 00003  10000       SSP                                         MARK0133
   00151  0560 00 0 00235  10001       LDQ    H                                    MARK0134
   00152  0040 00 0 00402  10011       TLQ    *+2                                  MARK0135
   00153  0131 00 0 00000  10000       XCA            MAX(H,T) IN AC               MARK0136
   00154  0402 00 0 00706  10001       SUB    HR09    DIVIDE BY 2**26              MARK0137
   00155  0520 00 0 00245  10001       ZET    P                                    MARK0138
   00156  0402 00 0 00706  10001       SUB    HR09    DIVIDE AGAIN IF D.P. TIME    MARK0139
   00157  0601 00 0 00175  10001       STO    DELU    DELTA SUB U                  MARK0140
   00160  0074 00 4 00414  10001       ISX    ABTB,4       INITIALIZE INTERRUPT S.R.  MARK0141
   00161  0020 00 0 00402  10011       TRA    *+2                                  MARK0142

BINARY CARD (NOT PUNCHED)
   00162  0020 00 0 00605  10001       TRA    RKC                                  MARK0143
   00163  0534 00 4 00231  10001       LXA    I4,4                                 MARK0144
   00164  0020 00 4 00003  10000       TRA    3,4          ERROR RETURN            MARK0145
   00165  0 00000 0 00000  10000  HC    PZE                                        MARK0146
   00166  0 00000 0 00000  10000  NI    PZE    0                                   MARK0147
   00167  0 00000 0 00000  10000  J     PZE                                        MARK0148
   00170  0 00000 0 00000  10000  TMIN  PZE                                        MARK0149
   00171  0 00000 0 00000  10000  TMIN2 PZE                                        MARK0150
   00172  0074 00 4 00000  10000  BMIN  ISX    **,4                                MARK0151
   00173  0 00000 0 00000  10000  TGO   PZE                                        MARK0152
   00174  0 00000 0 00000  10000  TGO2  PZE                                        MARK0153
   00175  0 00000 0 00000  10000  DELU  PZE                                        MARK0154
   00176  0 00000 0 00000  10000  TL    PZE                                        MARK0155
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          00177  0 00000 0 00000  10000      IL2 PZE                   MARK0156
          00200  0 00000 0 00000  10000       TR PZE                   MARK0157
          00201  0 00000 0 00000  10000      TR2 PZE                   MARK0158
          00202  200000000012     00001     TEMP BSS   10              MARK0159
          00214  0 00000 0 00000  10000    TRIGO PZE                   MARK0160
          00215  0 00000 0 00221  10001          PZE   TRG2            MARK0161

BINARY CARD (NOT PUNCHED)
          00216  0761 00 0 00000  10000     ALOS NOP                   MARK0162
          00217  0 00000 4 01777  10001     ASET PZE   SET,4           MARK0163
          00220  0 00000 4 01731  10001    AFLAG PZE   FLAG,4          MARK0164
          00221  200000000002     00001     TRG2 BSS   2               MARK0165
          00223  0 00000 1 00000  10000        Y PZE   **,1            MARK0166
          00224  0 00000 1 00000  10000     YDOT PZE   **,1            MARK0167
          00225  0 00000 1 00000  10000     Y(2) PZE   **,1            MARK0168
          00226  0 00000 1 00000  10000       Y0 PZE   **,1            MARK0169
          00227  0 00000 1 00000  10000    Y0(2) PZE   **,1            MARK0170
          00230  0 00000 0 00000  10000      MP1 PZE                   MARK0171
          00231  0 00000 0 00000  10000       I4 PZE                   MARK0172
          00232  0 00000 0 00000  10000        M PZE                   MARK0173
          00233  0 00000 0 00000  10000       NH PZE                   MARK0174
          00234  0 00000 0 00000  10000       ND PZE                   MARK0175
          00235  0 00000 0 00000  10000        H PZE                   MARK0176
          00236  0 00000 0 00000  10000        N PZE                   MARK0177
          00237  0 00000 0 00000  10000      (N) PZE                   MARK0178
          00240  0 00000 0 00000  10000       T1 PZE                   MARK0179
          00241  0 00000 0 00000  10000       T2 PZE                   MARK0180

BINARY CARD (NOT PUNCHED)
          00242  0 00000 1 00000  10000     L(M) PZE   **,1            MARK0181
          00243  0 00000 0 00000  10000    L(I1) PZE                   MARK0182
          00244  0 00000 0 00000  10000    L(I2) PZE                   MARK0183
          00245  0 00000 0 00000  10000        P PZE                   MARK0184
          00246  0 00000 0 00000  10000      PHI PZE                   MARK0185
          00247  0074 00 4 00000  10000     DER2 TSX   **,4            MARK0186
          00250  0074 00 4 00000  10000     DER1 TSX   **,4            MARK0187
          00251  0 00000 0 00000  10000        E PZE                   MARK0188
          00252  0 00000 0 00000  10000       HD PZE                   MARK0189
          00253  0 00000 0 00000  10000      HIC PZE                   MARK0190
          00254  0 00000 0 02747  10001    LSTRT PZE   START           MARK0191
          00255  000000000000     10000     DELO DEC   0               MARK0192
          00256  000000000000     10000    GSIGM DEC   0               MARK0193
          00257  0 00000 0 00000  10000      ERC PZE                   MARK0194
          00260  0 00000 1 00000  10000          PZE   **,1            MARK0195
          00261  0 00000 1 00000  10000          PZE   **,1            MARK0196
          00262  0 00000 1 00000  10000          PZE   **,1            MARK0197
          00263  0 00000 1 00000  10000          PZE   **,1            MARK0198
          00264  0 00000 1 00000  10000          PZE   **,1            MARK0199

BINARY CARD (NOT PUNCHED)
          00265  0 00000 1 00000  10000          PZE   **,1            MARK0200
          00266  0 00000 1 00000  10000          PZE   **,1            MARK0201
          00267  0 00000 1 00000  10000          PZE   **,1            MARK0202
          00270  0 00000 1 00000  10000          PZE   **,1            MARK0203
          00271  0 00000 1 00000  10000          PZE   **,1            MARK0204
          00272  0 00000 1 00000  10000          PZE   **,1            MARK0205
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   00273  0 00000 1 00000  10000   DELX PZE   **,1                                        MARK0206
   00274  0 00000 1 00000  10000        PZE   **,1                                        MARK0207
   00275  0 00000 1 00000  10000        PZE   **,1                                        MARK0208
   00276  0 00000 1 00000  10000        PZE   **,1                                        MARK0209
   00277  0 00000 1 00000  10000        PZE   **,1                                        MARK0210
   00300  0 00000 1 00000  10000        PZE   **,1                                        MARK0211
   00301  0 00000 1 00000  10000        PZE   **,1                                        MARK0212
   00302  0 00000 1 00000  10000        PZE   **,1                                        MARK0213
   00303  0 00000 1 00000  10000        PZE   **,1                                        MARK0214
   00304  0 00000 1 00000  10000        PZE   **,1                                        MARK0215
   00305  0 00000 1 00000  10000        PZE   **,1                                        MARK0216
   00306  0 00000 1 00000  10000        PZE   **,1                                        MARK0217
   00307  0 00000 1 00000  10000   DELY PZE   **,1                                        MARK0218

BINARY CARD (NOT PUNCHED)
   00310  0 00000 1 00000  10000        PZE   **,1                                        MARK0219
   00311  0 00000 1 00000  10000        PZE   **,1                                        MARK0220
   00312  0 00000 1 00000  10000        PZE   **,1                                        MARK0221
   00313  0 00000 1 00000  10000        PZE   **,1                                        MARK0222
   00314  0 00000 1 00000  10000        PZE   **,1                                        MARK0223
   00315  0 00000 1 00000  10000        PZE   **,1                                        MARK0224
   00316  0 00000 1 00000  10000        PZE   **,1                                        MARK0225
   00317  0 00000 1 00000  10000        PZE   **,1                                        MARK0226
   00320  0 00000 1 00000  10000        PZE   **,1                                        MARK0227
   00321  0 00000 1 00000  10000        PZE   **,1                                        MARK0228
   00322  0 00000 1 00000  10000        PZE   **,1                                        MARK0229
   00323  0 00000 1 00000  10000   DELZ PZE   **,1                                        MARK0230
   00324  0 00000 1 00000  10000     YN PZE   **,1                                        MARK0231
   00325  0 00000 1 00000  10000    YN2 PZE   **,1                                        MARK0232
   00326  0 00000 0 00000  10000  EUBAR PZE              UPPER LIMIT OF E(N+1)             MARK0233
   00327  0 00000 0 00000  10000  ELBAR PZE              LOINER LIMIT OF E(N+1)            MARK0234
   00330  0 00000 0 00000  10000  HMAXT PZE              MAXIMUM DELTA T                   MARK0235
   00331  0 00000 0 00000  10000  HMINT PZE              MINIMUM DELTA T                   MARK0236
   00332  0 00000 0 00000  10000  YCLOW PZE              LOWER BOUND OF Y(N+1)C            MARK0237

BINARY CARD (NOT PUNCHED)
   00333  0020 00 0 01000  10001  RGFRK TRA   RGINT                                       MARK0238
   00334  0534 00 1 00237  10001   ADDR LXA   (N),1        SET TABLE ADDRESSES            MARK0239
   00335  4634 00 1 00415  10011        SXD   *+13,1                                      MARK0240
   00336  0534 00 1 00236  10001        LXA   N,1                                         MARK0241
   00337  4634 00 1 00411  10001        SXD   RGAD,1                                      MARK0242
   00340  4634 00 1 00415  10011        SXD   *+13,1                                      MARK0243
   00341  4634 00 1 00421  10011        SXD   *+17,1                                      MARK0244
   00342  0534 00 1 00232  10001        LXA   M,1                                         MARK0245
   00343  1 00001 1 00401  10011        TXI   *+1,1,1                                     MARK0246
   00344  0634 00 1 00230  10001        SXA   MP1,1                                       MARK0247
   00345  1 00001 1 00401  10011        TXI   *+1,1,1                                     MARK0248
   00346  0634 00 1 00411  10011        SXA   *+9,1                                       MARK0249
   00347  0534 00 1 00242  10001        LXA   L(M),1                                      MARK0250
   00350  1 00007 1 00401  10011        TXI   *+1,1,7                                     MARK0251
   00351  0774 00 2 00005  10000        AXT   5,2                                         MARK0252
   00352  1 00400 1 00401  11111        TXI   *+1,1,*                                     MARK0253
   00353  0754 00 1 00400  10011        PXA   *,1                                         MARK0254
   00354  0621 00 2 05001  10011        STA   Y0(2)+1,2                                   MARK0255
   00355  1 00400 1 00401  11111        TXI   *+1,1,*      N IN DECRE                     MARK0256
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BINARY CARD (NOT PUNCHED)
   00356  2 00001 2 40403  10011         TIX    *-3,2,1                                      MARK0257
   00357  0774 00 2 00400  10011         AXT    *,2           M+2 IN ADD                     MARK0258
   00360  0754 00 1 00400  10011         PXA    *,1                                          MARK0259
   00361  0621 00 2 00274  10001         STA    DELX+1,2                                     MARK0260
   00362  1 00400 1 00401  11111         TXI    *+1,1,*       N IN DECRE                     MARK0261
   00363  2 00001 2 40403  10011         TIX    *-3,2,1                                      MARK0262
   00364  0534 00 2 00236  10001         LXA    N,2                                          MARK0263
   00365  4634 00 2 00405  10011         SXD    *+5,2                                        MARK0264
   00366  0534 00 2 00230  10001         LXA    MP1,2                                        MARK0265
   00367  1 00001 2 00401  10011         TXI    *+1,2,1                                      MARK0266
   00370  0754 00 1 00400  10011         PXA    *,1                                          MARK0267
   00371  0621 00 2 00310  10001         STA    DELY+1,2                                     MARK0268
   00372  1 00400 1 00401  11111         TXI    *+1,1,*       N IN DECRE                     MARK0269
   00373  2 00001 2 40403  10011         TIX    *-3,2,1                                      MARK0270
   00374  4520 00 0 00251  10001         NZT    E                                            MARK0271
   00375  0020 00 0 00413  10001         TRA    RGAD+2                                       MARK0272
   00376  0534 00 2 00236  10001         LXA    N,2                                          MARK0273
   00377  4634 00 2 00405  10011         SXD    *+5,2                                        MARK0274
   00400  0534 00 2 00230  10001         LXA    MP1,2                                        MARK0275

BINARY CARD (NOT PUNCHED)
   00401  1 00001 2 00401  10011         TXI    *+1,2,1                                      MARK0276
   00402  0754 00 1 00400  10011         PXA    *,1                                          MARK0277
   00403  0621 00 2 00324  10001         STA    DELZ+1,2                                     MARK0278
   00404  1 00000 1 00401  10011         TXI    *+1,1,**                                     MARK0279
   00405  2 00001 2 40403  10011         TIX    *-3,2,1                                      MARK0280
   00406  0774 00 2 00002  10000         AXT    2,2                                          MARK0281
   00407  0754 00 1 00400  10011         PXA    *,1                                          MARK0282
   00410  0621 00 2 00000  10011         STA    YN2+1,2                                      MARK0283
          0 00001 7 00325  10001
   00411  1 00400 1 00401  11111    RGAD TXI    *+1,1,*       N IN DECRE                     MARK0284
   00412  2 00001 2 40403  10011         TIX    *-3,2,1                                      MARK0285
   00413  0020 00 4 00001  10000         TRA    1,4                                          MARK0286
   00414  0634 00 1 00573  10001    ABTB SXA    HA01,1                                       MARK0287
   00415  0634 00 2 00572  10001         SXA    HA02,2                                       MARK0288
   00416  0634 00 4 00571  10001         SXA    HA03,4                                       MARK0289
                                                ASET AND AFLAG SHOULD BE ASSEMBLED AS        MARK0290
                                                ASET PZE SET,4   AND AFLAG PZE FLAG,4        MARK0291
   00417  0500 00 0 00602  10001         CLA    HA12                                         MARK0292
   00420  0622 00 0 00217  10001         STD    ASET          ASET NOW CONTAINS NOP          MARK0293
   00421  0622 00 0 00220  10001         STD    AFLAG         AFLAG NOW CONTAINS NOP         MARK0294
   00422  0500 00 0 00214  10001         CLA    TRIGO                                        MARK0295

BINARY CARD (NOT PUNCHED)
   00423  0621 00 0 00172  10001         STA    BMIN                                         MARK0296
   00424  0500 00 0 00215  10001         CLA    TRIGO+1                                      MARK0297
   00425  0402 00 0 00440  10001         SUB    HA11                                         MARK0298
   00426  0621 00 0 00401  10011         STA    *+1                                          MARK0299
   00427  0500 00 0 00000  10000         CLA    **                                           MARK0300
   00430  0601 00 0 00171  10001         STO    TMIN2                                        MARK0301
   00431  0500 60 0 00215  10001         CLA*   TRIGO+1                                      MARK0302
   00432  0601 00 0 00170  10001         STO    TMIN                                         MARK0303
   00433  0534 00 1 00251  10001         LXA    I4,1          FIND MARK                      MARK0304
   00434  0500 00 1 00004  10000    HA04 CLA    4,1                                          MARK0305
   00435  0100 00 0 00505  10001         TZE    HA10          END OF TRIGGERS                MARK0306
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       00436  0120 00 0 00402  10011       TPL   **2                                            MARK0307
       00437  1 77776 1 00434  10001       TXI   HA04,1,-2      SKIP NEGATIVE TRIGGERS          MARK0308
       00440  4734 00 2 00001  10000  HA11 PDX   1,2                SET DEP. VAR. FLAG          MARK0309
       00441  7 00000 2 00405  10011       TXL   **5,2,0             IF INDEPENDENT VARIABLE, JUMP MARK0310
       00442  0500 00 0 00603  10001       CLA   HA13                                           MARK0311
       00443  0622 00 0 00217  10001       STD   ASET           ASET NOW CONTAINS TSX           MARK0312
       00444  0622 00 0 00220  10001       STD   AFLAG          AFLAG NOW CONTAINS TSX          MARK0313
       00445  1 77776 1 00434  10001       TXI   HA04,1,-2                                      MARK0314

BINARY CARD (NOT PUNCHED)
       00446  0500 00 1 00005  10000       CLA   5,1                                            MARK0315
       00447  0621 00 0 00452  10001       STA   HA05                                           MARK0316
       00450  0402 00 0 00440  10001       SUB   HA11                                           MARK0317
       00451  0621 00 0 00470  10001       STA   HA06                                           MARK0318
       00452  0500 00 0 00000  10000  HA05 CLA   **                 T1(I)                       MARK0319
       00453  4520 00 0 00245  10001       NZT   P                                              MARK0320
       00454  0020 00 0 00404  10011       TRA   **4                                            MARK0321
       00455  0300 60 0 00470  10001       FAD*  HA06               T2(I)                       MARK0322
       00456  4600 60 0 00470  10001       STQ*  HA06                                           MARK0323
       00457  0601 60 0 00452  10001       STO*  HA05               T1(I)                       MARK0324
       00460  0340 00 0 00170  10001       CAS   TMIN                                           MARK0325
       00461  1 77776 1 00434  10001       TXI   HA04,1,-2      T1(I)-TMIN=+,CONTINUE SEARCH    MARK0326
       00462  0020 00 0 00473  10001       TRA   HA07               T1(I)-TMIN=0,CHECK TMIN2 IF P=1 MARK0327
       00463  0601 00 0 00170  10001       STO   TMIN               T1(I)-TMIN=-,REPLACE TMIN AND TMIN2 MARK0328
       00464  0500 00 1 00004  10000       CLA   4,1                                            MARK0329
       00465  0621 00 0 00172  10001       STA   BMIN                                           MARK0330
       00466  4520 00 0 00245  10001       NZT   P                                              MARK0331
       00467  1 77776 1 00434  10001       TXI   HA04,1,-2          P=0, CONTINUE SEARCH        MARK0332
       00470  0500 00 0 00000  10000  HA06 CLA   **                 T2 (I)                      MARK0333

BINARY CARD (NOT PUNCHED)
       00471  0601 00 0 00171  10001       STO   TMIN2                                          MARK0334
       00472  1 77776 1 00434  10001       TXI   HA04,1,-2          NEW TMIN TMIN2, CONTINUE SEARCH MARK0335
       00473  4520 00 0 00245  10001  HA07 NZT   P                                              MARK0336
       00474  1 77776 1 00434  10001       TXI   HA04,1,-2          P=0,CONTINUE SEARCH         MARK0337
       00475  0500 60 0 00470  10001       CLA*  HA06               T2(I)                       MARK0338
       00476  0340 00 0 00171  10001       CAS   TMIN2                                          MARK0339
       00477  0761 00 0 00000  10000       NOP                                                  MARK0340
       00500  1 77776 1 00434  10001       TXI   HA04,1,-2          T2(I)-TMIN2=+,CONTINUE SEARCH MARK0341
       00501  0601 00 0 00171  10001       STO   TMIN2              T2(I)-TMIN2=-, REPLACE TMIN2 MARK0342
       00502  0500 00 1 00004  10000       CLA   4,1                                            MARK0343
       00503  0621 00 0 00172  10001       STA   BMIN                                           MARK0344
       00504  1 77776 1 00434  10001       TXI   HA04,1,-2          CONTINUE SEARCH             MARK0345
       00505  0534 00 1 00231  10001  HA10 LXA   I4,1               FIND MARK                   MARK0346
       00506  0500 00 1 00002  10000       CLA   2,1                                            MARK0347
       00507  0621 00 0 00250  10001       STA   DER1                                           MARK0348
       00510  0600 00 0 00202  10001       STZ   TEMP                                           MARK0349
       00511  0625 00 0 00202  10001       STT   TEMP               PHI IN T(TEMP)              MARK0350
       00512  0771 00 0 00022  10000       ARS   18                                             MARK0351
       00513  0621 00 0 00247  10001       STA   DER2                                           MARK0352

BINARY CARD (NOT PUNCHED)
       00514  0500 00 1 00001  10000       CLA   1,1                                            MARK0353
       00515  0622 00 0 00525  10001       STD   HA08                                           MARK0354
       00516  0771 00 0 00022  10000       ARS   18                                             MARK0355
       00517  0601 00 0 00203  10001       STO TEMP+1                                           MARK0356
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00520  4100 00 0 00404  10011          TNZ    **4             GO COMPARE EOS WITH A (AEOS)      MARK0357
00521  0500 00 0 00602  10001          CLA    HA12                                              MARK0358
00522  0622 00 0 00216  10001          STD    AEOS            SET C(AEOS)=NOP                   MARK0359
00523  0020 00 0 00534  10001          TRA    HA09            CONTINUE                          MARK0360
00524  0535 00 2 00216  10001          LAC    AEOS,2                                            MARK0361
00525  1 00000 2 00401  10011   HA08   TXI    *+1,2,**                                          MARK0362
00526  7 00000 2 00534  10001          TXL    HA09,2,0        EOS=A(AEOS)                       MARK0363
00527  0500 00 0 00603  10001          CLA    HA13                                              MARK0364
00530  0601 00 0 00216  10001          STO    AEOS            C(AEOS)=TSX **,4                  MARK0365
00531  0500 00 0 00203  10001          CLA TEMP+1                                               MARK0366
00532  0621 00 0 00216  10001          STA    AEOS            A(AEOS)=NEW EOS                   MARK0367
00533  0522 00 0 00216  10001          XEC    AEOS                                              MARK0368
00534  0500 00 0 00202  10001   HA09   CLA    TEMP                                              MARK0369
00535  0771 00 0 00017  10000          ARS    15                                                MARK0370
00536  0601 00 0 00202  10001          STO    TEMP            PHI IN A(TEMP)                    MARK0371

BINARY CARD (NOT PUNCHED)
00537  0402 00 0 00246  10001          SUB    PHI                                               MARK0372
00540  0100 00 0 00542  10001          TZE    HA16             PHI UNCHANGED                    MARK0373
00541  0020 00 0 00001  10001          TRA    RSTRT           PHI AND RESTART                   MARK0374
00542  0774 00 1 77774  10000   HA16   AXT    -4,1                                              MARK0375
00543  0500 60 0 00242  10001          CLA*   L(M)        PICK UP N,,(N)                        MARK0376
00544  0771 00 0 00022  10000          ARS    18                                                MARK0377
00545  0340 00 0 00237  10001          CAS    (N)                                               MARK0378
00546  0020 00 0 00001  10001          TRA    RSTRT             (N) BIGGER, RESTART             MARK0379
00547  0020 00 0 00403  10011          TRA    *+3         (N) UNCHANGED, CONTINUE               MARK0380
00550  0601 00 0 00237  10001          STO    (N)                                               MARK0381
00551  0074 00 4 00334  10001          TSX    ADDR,4      FIX DELX ADDRESSES FOR NEW (N)        MARK0382
00552  0774 00 1 77775  10000          AXT    -3,1                                              MARK0383
00553  0500 60 0 00242  10001          CLA*   L(M)                                              MARK0384
00554  0601 00 0 00235  10001          STO    H                                                 MARK0385
00555  0774 00 1 77777  10000          AXT    -1,1            MODIFY NH AND ND BY               MARK0386
00556  0500 60 0 00242  10001          CLA*   L(M)            AMOUNT OF USER CHANGE             MARK0387
00557  0400 00 0 00233  10001          ADD    NH                                                MARK0388
00560  0621 00 0 00233  10001          STA    NH                                                MARK0389
00561  0767 00 0 00022  10000          ALS    18                                                MARK0390

BINARY CARD (NOT PUNCHED)
00562  0601 60 0 00242  10001          STO*   L(M)                                              MARK0391
00563  1 77777 1 00401  10011          TXI    *+1,1,-1                                          MARK0392
00564  0500 60 0 00242  10001          CLA*   L(M)                                              MARK0393
00565  0400 00 0 00234  10001          ADD    ND                                                MARK0394
00566  0621 00 0 00234  10001          STA    ND                                                MARK0395
00567  0767 00 0 00022  10000          ALS    18                                                MARK0396
00570  0601 60 0 00242  10001          STO*   L(M)                                              MARK0397
00571  0774 00 4 00000  10000   HA03   AXT    **,4                                              MARK0398
00572  0774 00 2 00000  10000   HA02   AXT    **,2                                              MARK0399
00573  0774 00 1 00000  10000   HA01   AXT    **,1                                              MARK0400
00574  0500 00 0 00170  10001          CLA    TMIN                                              MARK0401
00575  0302 00 0 00240  10001          FSB    T1              IF TMIN-T1=- AND P=0              MARK0402
00576  4520 00 0 00245  10001          NZT    P               THEN CHECK TO SEE IF TMIN         MARK0403
00577  0300 00 0 00175  10001          FAD    DELU            IS WITHIN DELU OF T1              MARK0404
00600  4120 00 4 00001  10000          TMI    1,4                                               MARK0405
00601  0020 00 4 00002  10000          TRA    2,4                                               MARK0406
00602  0761 00 0 00000  10000   HA12   NOP                                                      MARK0407
00603  0074 00 4 00000  10000   HA13   TSX    **,4                                              MARK0408
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        00604  000000000002      10000   HA14 OCT   2                                          MARK0409

BINARY CARD (NOT PUNCHED)
        00605  0500 00 0 00240   10001   RKC  CLA   T1                                         MARK0410
        00606  0760 00 0 00003   10000        SSP                                              MARK0411
        00607  0560 00 0 00255   10001        LDQ   H                                          MARK0412
        00610  0040 00 0 00402   10011        TLQ   *+2                                        MARK0413
        00611  0131 00 0 00000   10000        XCA               MAX (H,T) IN AC                MARK0414
        00612  0402 00 0 00706   10001        SUB   HR09        DIVIDE BY 2**26                MARK0415
        00613  0520 00 0 00245   10001        ZET   P                                          MARK0416
        00614  0402 00 0 00710   10001        SUB   HR13        DIVIDE AGAIN IF D.P. TIME      MARK0417
        00615  0601 00 0 00175   10001        STO   DELU        DELTA                          MARK0418
        00616  0500 00 0 00170   10001   HR04 CLA   TMIN                                       MARK0419
        00617  0302 00 0 00240   10001        FSB   T1                                         MARK0420
        00620  0601 00 0 00202   10001        STO   TEMP                                       MARK0421
        00621  0131 00 0 00000   10000        XCA                                              MARK0422
        00622  0302 00 0 00241   10001        FSB   T2                                         MARK0423
        00623  0300 00 0 00171   10001        FAD   TMIN2                                      MARK0424
        00624  0300 00 0 00202   10001        FAD   TEMP                                       MARK0425
        00625  0602 00 0 00711   10001        SLW   HR03                                       MARK0426
        00626  0300 00 0 00175   10001        FAD   DELU                                       MARK0427
        00627  0120 00 0 00403   10011        TPL   *+3                                        MARK0428

BINARY CARD (NOT PUNCHED)
        00630  0534 00 4 00231   10001   HR11 LXA   I4,4                                       MARK0429
        00631  0020 00 4 00003   10000        TRA   3,4         TIME ERROR                     MARK0430
        00632  0500 00 0 00711   10001        CLA   HR03                                       MARK0431
        00633  0560 00 0 00175   10001        LDQ   DELU                                       MARK0432
        00634  0040 00 0 00642   10001        TLQ   HR02        TRANSFER IF T NOT WITHIN       MARK0433
        00635  0522 00 0 00172   10001        XEC   BMIN        DELTA OF TMIN                  MARK0434
        00636  0020 00 0 00401   10011        TRA   *+1                                        MARK0435
        00637  0074 00 4 00414   10001        TSX   ABTB,4      GET NEW TMIN                   MARK0436
        00640  0020 00 0 00630   10001        TRA   HR11                                       MARK0437
        00641  0020 00 0 00616   10001        TRA   HR04                                       MARK0438
        00642  0500 00 0 00711   10001   HR02 CLA   HR03        TMIN-T                         MARK0439
        00643  0560 00 0 00255   10001        LDQ   H                                          MARK0440
        00644  4600 00 0 01400   10011        STQ   HC                                         MARK0441
        00645  0040 00 0 00402   10011        TLQ   *+2                                        MARK0442
        00646  0601 00 0 01400   10011        STO   HC          HC=MIN(H,TMIN-T)               MARK0443
        00647  0522 00 0 00217   10001        XEC   ASET                                       MARK0444
        00650  0074 00 4 01131   10001        TSX   KUTTA,4     INTEGRATE TO T+DT              MARK0445
        00651  0500 00 0 00240   10001        CLA   T1                                         MARK0446
        00652  0560 00 0 00241   10001        LDQ   T2                                         MARK0447

BINARY CARD (NOT PUNCHED)
        00653  0601 00 0 02400   10011        STO   TG0                                        MARK0448
        00654  4600 00 0 00174   10001        STQ   TG02                                       MARK0449
        00655  0522 00 0 00216   10001        XEC   AEOS                                       MARK0450
        00656  0522 00 0 00220   10001        XEC   AFLAG                                      MARK0451
        00657  0020 00 0 00605   10001        TRA   RKC         NORMAL RETURN                  MARK0452
        00660  0074 00 4 02263   10001   HR12 TSX   SRCH,4      FLAG RETURN                    MARK0453
        00661  0020 00 0 00606   10001        TRA   HR05        CON                            MARK0454
        00662  0601 00 0 01400   10011        STO   HC          RAK                            MARK0455
        00663  0074 00 4 01131   10001   HR01 TSX   KUTTA,4                                    MARK0456
        00664  0522 00 0 00216   10001        XEC   AEOS                                       MARK0457
        00665  0020 00 0 00600   10001        TRA   HR12                                       MARK0458
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00666  0534 00 1 00231  10001   HR05 LXA   I4,1                                     MARK0459
00667  0500 00 1 00004  10000   HR07 CLA   4,1                                      MARK0460
00670  0100 00 0 00605  10001        TZE   RKC          END OF TRIGGERS             MARK0461
00671  4320 00 0 00707  10001        ANA   HR10                                     MARK0462
00672  0100 00 0 00705  10001        TZE   HR08                                     MARK0463
00673  0634 00 1 00405  10011        SXA   *+5,1
00674  0500 00 1 00004  10000        CLA   4,1                                      MARK0464
00675  0621 00 0 00401  10011        STA   *+1                                      MARK0465

BINARY CARD (NOT PUNCHED)
00676  0074 00 4 00000  10000        TSX   **,4         EXECUTE BMIN                MARK0466
00677  0020 00 0 00401  10011        TRA   *+1                                      MARK0467
00700  0774 00 1 00000  10000        AXT   **,1
00701  0500 00 0 40402  10011        CLA   *-2
00702  0625 00 1 00004  10000        STT   4,1     SET TAG OF EXECUTED TRIGGER = 0
00703  0074 00 4 00414  10001        TSX   ABTB,4       UPDATE TMIN                 MARK0468
00704  0020 00 0 00630  10001        TRA   HR11                                     MARK0469
00705  1 77776 1 00667  10001   HR08 TXI   HR07,1,-2                                MARK0470
00706  032000000000     10000   HR09 OCT   32000000000                              MARK0471
00707  000000400000     10000   HR10 OCT   400000                                   MARK0472
00710  032000000000     10000   HR13 OCT   32000000000                              MARK0473
00711  000000000000     10000   HR03 OCT   0                                        MARK0474
00712  4520 00 0 00245  10001   AMC  NZT   P            ADAMS-MOULTON CONTROL       MARK0475
00713  0020 00 0 00405  10011        TRA   *+5                                      MARK0476
00714  0074 00 4 02716  10001        TSX   DSUB,4                                   MARK0477
00715  0 00170 0 00240  10101        PZE   T1,0,TMIN                                MARK0478
00716  0760 00 0 00003  10000        SSP                                            MARK0479
00717  0020 00 0 00404  10011        TRA   *+4                                      MARK0480
00720  0500 00 0 00240  10001        CLA   T1                                       MARK0481

BINARY CARD (NOT PUNCHED)
00721  0302 00 0 00170  10001        FSB   TMIN                                     MARK0482
00722  0760 00 0 00003  10000        SSP                                            MARK0483
00723  0340 00 0 00175  10001        CAS   DELU                                     MARK0484
00724  0020 00 0 00734  10001        TRA   GT1                                      MARK0485
00725  0761 00 0 00000  10000        NOP                                            MARK0486
00726  0522 00 0 00172  10001        XEC   BMIN                                     MARK0487
00727  0020 00 0 00402  10011        TRA   *+2                                      MARK0488
00730  0020 00 0 00001  10001        TRA   RSTRT        RESTART                     MARK0489
00731  0074 00 4 00414  10001   GT0  TSX   ABTB,4       ENTRY FROM START            MARK0490
00732  0020 00 0 01127  10001        TRA   GT10+1       ERROR RETURN                MARK0491
00733  0020 00 0 00712  10001        TRA   AMC                                      MARK0492
00734  0522 00 0 00217  10001   GT1  XEC   ASET         DO SET ROUTINE              MARK0493
00735  4520 00 0 00245  10001        NZT   P                                        MARK0494
00736  0020 00 0 00405  10011        TRA   *+5                                      MARK0495
00737  0074 00 4 02716  10001        TSX   DSUB,4                                   MARK0496
00740  0 02400 0 00240  11101        PZE   T1,0,TG0                                 MARK0497
00741  0760 00 0 00003  10000        SSP                                            MARK0498
00742  0020 00 0 00404  10011        TRA   *+4                                      MARK0499
00743  0500 00 0 00240  10001        CLA   T1                                       MARK0500

BINARY CARD (NOT PUNCHED)
00744  0302 00 0 02400  10011        FSB   TG0                                      MARK0501
00745  0760 00 0 00003  10000        SSP                                            MARK0502
00746  0340 00 0 00175  10001        CAS   DELU                                     MARK0503
00747  0020 00 0 01015  10001        TRA   GT3                                      MARK0504
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00750  0761 00 0 00000  10000        NOP                                  MARK0505
00751  0761 00 0 00000  10000   GT2  NOP             AEC FORK             MARK0506
00752  4520 00 0 00233  10001        NZT   NH                             MARK0507
00753  0020 00 0 00410  10011        TRA   *+8                            MARK0508
00754  0074 00 4 03162  10001        TSX   X.50,4    HALVF INTERVAL       MARK0509
00755  0774 00 1 77777  10000        AXT   -1,1                           MARK0510
00756  0534 00 2 00233  10001        LXA   NH,2                           MARK0511
00757  1 77777 2 00401  10011        TXI   *+1,2,-1                       MARK0512
00760  0634 00 2 00233  10001        SXA   NH,2                           MARK0513
00761  4754 00 2 00000  10000        PXD   0,2                            MARK0514
00762  0622 60 0 00242  10001        STD*  L(M)                           MARK0515
00763  4520 00 0 00234  10001        NZT   ND                             MARK0516
00764  0020 00 0 00414  10011        TRA   *+12                           MARK0517
00765  0520 00 0 00252  10001        ZET   HD                             MARK0518
00766  0020 00 0 00412  10011        TRA   *+10                           MARK0519

BINARY CARD (NOT PUNCHED)
00767  0074 00 4 03024  10001        TSX   X2,0,4    DOUBLE INTERVAL      MARK0520
00770  0774 00 1 77776  10000        AXT   -2,1                           MARK0521
00771  0534 00 2 00234  10001        LXA   ND,2                           MARK0522
00772  1 77777 2 00401  10011        TXI   *+1,2,-1                       MARK0523
00773  0634 00 2 00234  10001        SXA   ND,2                           MARK0524
00774  4754 00 2 00000  10000        PXD   0,2                            MARK0525
00775  0622 60 0 00242  10001        STD*  L(M)                           MARK0526
00776  0074 00 4 00414  10001        TSX   ARTB,4    FIND NEW TMIN        MARK0527
00777  0020 00 0 01127  10001        TRA   GT10+1    ERROR RETURN         MARK0528
01000  0074 00 4 01250  10001 RGINT  TSX   ADAMS,4   INTEGRATE            MARK0529
01001  0500 00 0 00240  10001        CLA   T1                             MARK0530
01002  0560 00 0 00241  10001        LDQ   T2                             MARK0531
01003  0601 00 0 02400  10011        STO   TG0                            MARK0532
01004  4600 00 0 00174  10001        STQ   TG02                           MARK0533
01005  0760 00 0 00003  10000        SSP             FORM DELU            MARK0534
01006  0560 00 0 01400  10011        LDQ   HC                             MARK0535
01007  0040 00 0 00402  10011        TLQ   *+2                            MARK0536
01010  0131 00 0 00000  10000        XCA             HC IN AC             MARK0537
01011  0520 00 0 00245  10001        ZET   P                              MARK0538

BINARY CARD (NOT PUNCHED)
01012  0402 00 0 01126  10001        SUB   GT10                           MARK0539
01013  0402 00 0 01126  10001        SUB   GT10                           MARK0540
01014  0601 00 0 00175  10001        STO   DELU                           MARK0541
01015  0500 00 0 00175  10001   GT3  CLA   DELU                           MARK0542
01016  0760 00 0 00002  10000        CHS                                  MARK0543
01017  0300 00 0 00174  10001        FAD   TG02                           MARK0544
01020  0300 00 0 02400  10011        FAD   TG0                            MARK0545
01021  0601 00 0 00202  10001        STO   TEMP                           MARK0546
01022  4600 00 0 00203  10001        STQ   TEMP+1                         MARK0547
01023  0500 00 0 00202  10001        CLA   TEMP                           MARK0548
01024  0340 00 0 00170  10001        CAS   TMIN                           MARK0549
01025  0020 00 0 01046  10001        TRA   GT5                            MARK0550
01026  0020 00 0 00402  10011        TRA   *+2                            MARK0551
01027  0020 00 0 01034  10001        TRA   GT4                            MARK0552
01030  0500 00 0 00203  10001        CLA   TEMP+1                         MARK0553
01031  0340 00 0 00171  10001        CAS   TMIN2                          MARK0554
01032  0761 00 0 00000  10000        NOP                                  MARK0555
01033  0020 00 0 01046  10001        TRA   GT5                            MARK0556
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       01034  0500 00 0 02400  10011   GT4 CLA   TGO                                  MARK0557

BINARY CARD (NOT PUNCHED)
       01035  0601 00 0 00240  10001       STO   T1                                   MARK0558
       01036  0601 60 0 00243  10001       STO*  L(T1)                                MARK0559
       01037  0500 00 0 00174  10001       CLA   TGO2                                 MARK0560
       01040  0601 00 0 00241  10001       STO   T2                                   MARK0561
       01041  0601 60 0 00244  10001       STO*  L(T2)                                MARK0562
       01042  0074 00 4 03007  10001       TSX   PUTB,4                               MARK0563
       01043  0522 00 0 00216  10001       XEC   AEOS                                 MARK0564
       01044  0020 00 0 01055  10001       TRA   GT6                                  MARK0565
       01045  0020 00 0 00001  10001       TRA   RSTRT         RESTART                MARK0566
       01046  0500 00 0 00170  10001   GT5 CLA   TMIN                                 MARK0567
       01047  0601 00 0 00240  10001       STO   T1                                   MARK0568
       01050  0601 60 0 00243  10001       STO*  L(T1)                                MARK0569
       01051  0500 00 0 00171  10001       CLA   TMIN2                                MARK0570
       01052  0601 00 0 00241  10001       STO   T2                                   MARK0571
       01053  0601 60 0 00244  10001       STO*  L(T2)                                MARK0572
       01054  0074 00 4 02442  10001       TSX   INTRP,4                              MARK0573
       01055  0522 00 0 00220  10001   GT6 XEC   AFLAG         FLAG SUBROUTINE        MARK0574
       01056  0020 00 0 00712  10001       TRA   AMC                                  MARK0575
       01057  0074 00 4 02263  10001       TSX   SRCH,4        FLAG RETURN            MARK0576

BINARY CARD (NOT PUNCHED)
       01060  0020 00 0 01072  10001       TRA   GT8                                  MARK0577
       01061  0500 00 0 00241  10001       CLA   T2                                   MARK0578
       01062  0300 00 0 00253  10001       FAD   HIC                                  MARK0579
       01063  0300 00 0 00240  10001       FAD   T1                                   MARK0580
       01064  0601 00 0 00240  10001       STO   T1                                   MARK0581
       01065  0601 60 0 00243  10001       STO*  L(T1)                                MARK0582
       01066  4600 00 0 00241  10001       STQ   T2                                   MARK0583
       01067  4600 60 0 00244  10001       STQ*  L(T2)                                MARK0584
       01070  0074 00 4 02442  10001       TSX   INTRP,4                              MARK0585
       01071  0020 00 0 01057  10001       TRA   GT6+2                                MARK0586
       01072  0600 00 0 01125  10001   GT8 STZ   STAR                                 MARK0587
       01073  0534 00 4 00231  10001       LXA   I4,4                                 MARK0588
       01074  0500 00 4 00004  10000       CLA   4,4                                  MARK0589
       01075  0100 00 0 01114  10001       TZE   GT9                                  MARK0590
       01076  4120 00 0 01101  10001       TMI   GT11                                 MARK0591
       01077  0771 00 0 00021  10000       ARS   17                                   MARK0592
       01100  0760 00 0 00001  10000       LRT                                        MARK0593
       01101  1 77776 4 01074  10001  GT11 TXI   GT8+2,4,-2                           MARK0594
       01102  0634 00 4 00406  10011       SXA   *+6,4                                MARK0595

BINARY CARD (NOT PUNCHED)
       01103  0500 00 4 00004  10000       CLA   4,4                                  MARK0596
       01104  0621 00 0 00401  10011       STA   *+1                                  MARK0597
       01105  0074 00 4 00400  10011       TSX   *,4           EXECUTE INTERRUPTION   MARK0598
       01106  0020 00 0 00402  10011       TRA   *+2                                  MARK0599
       01107  0020 00 0 01122  10001       TRA   GT12                                 MARK0600
       01110  0774 00 4 00400  10011  GT13 AXT   *,4                                  MARK0601
       01111  0500 00 0 40402  10011       CLA   *-2        CLEAR 5 FROM TAG          MARK0602
       01112  0625 00 4 00004  10000       STT   4,4                                  MARK0603
       01113  0020 00 0 01101  10001       TRA   GT11                                 MARK0604
       01114  0074 00 4 00414  10001   GT9 TSX   ABTB,4                               MARK0605
       01115  0020 00 0 01127  10001       TRA   GT10+1        ERROR RETURN           MARK0606
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      01116  0522 00 0 00217  10001        XEC   ASET              SET SUBROUTINE           MARK0607
      01117  0520 00 0 01125  10001        ZET   STAR                                       MARK0608
      01120  0020 00 0 00001  10001        TRA   RSTRT                                      MARK0609
      01121  0020 00 0 01015  10001        TRA   GT3                                        MARK0610
      01122  0500 00 0 00400  10011  GT12  CLA   *                                          MARK0611
      01123  0601 00 0 01125  10001        STO   STAR                                       MARK0612
      01124  0020 00 0 01110  10001        TRA   GT13                                       MARK0613
      01125  0 00000 0 00000  10000  STAR  PZE                     FLAG FOR RESTART         MARK0614

BINARY CARD (NOT PUNCHED)
      01126  032000000000     10000  GT10  OCT   320000000000                               MARK0615
      01127  0534 00 4 00231  10001        LXA   14,4                                       MARK0616
      01130  0020 00 4 00003  10000        TRA   3,4               ERROR RETURN             MARK0617
      01131  0634 00 1 01201  10001  KUTA  SXA   HK08,1                                     MARK0618
      01132  0634 00 2 01202  10001        SXA   HK09,2                                     MARK0619
      01133  0634 00 4 01203  10001        SXA   HK10,4                                     MARK0620
      01134  0500 00 0 01400  10011        CLA   HC                                         MARK0621
      01135  0240 00 0 01246  10001        FDH   HK12                                       MARK0622
      01136  4600 00 0 00203  10001        STQ   TEMP+1            DT/2                     MARK0623
      01137  0600 00 0 00202  10001        STZ   TEMP                                       MARK0624
      01140  0534 00 1 00237  10001        LXA   (N),1                                      MARK0625
      01141  0500 60 0 03000  10011        CLA*  Y                                          MARK0626
      01142  0601 60 0 04400  10011        STO*  Y0                SAVE INITIAL VALUES OF Y(I)  MARK0627
      01143  2 00001 1 40402  10011        TIX   *-2,1,1                                    MARK0628
      01144  0774 00 4 00004  10000        AXT   4,4                                        MARK0629
      01145  0534 00 1 00237  10001  HK01  LXA   (N),1                                      MARK0630
      01146  0754 00 4 00001  10000        PXA   1,4                                        MARK0631
      01147  4320 00 0 40401  10011        ANA   *-1               GET BIT 35               MARK0632
      01150  0734 00 2 00000  10000        PAX   ,2                C(XR2)=1 OR 0            MARK0633

BINARY CARD (NOT PUNCHED)
      01151  0560 60 0 03400  10011        LDQ*  YDOT                                       MARK0634
      01152  0260 00 0 01400  10011        FMP   HC                                         MARK0635
      01153  0020 60 4 01245  10001        TRA*  HK11,4            SWITCH FOR PASSES 1-4    MARK0636
      01154  2 00001 1 40403  10011  HK03  TIX   *-3,1,1           DO (N)                   MARK0637
      01155  0500 00 2 00203  10001        CLA   TEMP+1,2          GET 0 OR H/2             MARK0638
      01156  0300 60 0 00243  10001        FAD*  L(T1)                                      MARK0639
      01157  0601 60 0 00243  10001        STO*  L(T1)                                      MARK0640
      01160  0131 00 0 00000  10000        XCA                                              MARK0641
      01161  0300 60 0 00244  10001        FAD*  L(T2)                                      MARK0642
      01162  0300 60 0 00243  10001        FAD*  L(T1)                                      MARK0643
      01163  4600 60 0 00244  10001        STQ*  L(T2)                                      MARK0644
      01164  0601 60 0 00243  10001        STO*  L(T1)                                      MARK0645
      01165  0634 00 1 00404  10011        SXA   **+4,1                                     MARK0646
      01166  0634 00 2 00404  10011        SXA   **+4,2                                     MARK0647
      01167  0634 00 4 00404  10011        SXA   **+4,4                                     MARK0648
      01170  0522 00 2 00250  10001        XEC   DFR1,2            DO DFR1 OR DFR2          MARK0649
      01171  0774 00 1 00000  10000        AXT   **,1                                       MARK0650
      01172  0774 00 2 00000  10000        AXT   **,2                                       MARK0651
      01173  0774 00 4 00000  10000        AXT   **,4                                       MARK0652

BINARY CARD (NOT PUNCHED)
      01174  2 00001 4 01145  10001        TIX   HK01,4,1          OUTER LOOP, DO 4         MARK0653
      01175  0500 60 0 00243  10001        CLA*  L(T1)             NEW TIME IN BUFFER       MARK0654
      01176  0560 60 0 00244  10001        LDQ*  L(T2)                                      MARK0655
      01177  0601 00 0 00240  10001        STO   T1                                         MARK0656
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01200  4600 00 0 00241  10001          STO    T2                                     MARK0657
01201  0774 00 1 00000  10000    HK08  AXT    **,1                                   MARK0658
01202  0774 00 2 00000  10000    HK09  AXT    **,2                                   MARK0659
01203  0774 00 4 00000  10000    HK10  AXT    **,4                                   MARK0660
01204  0020 00 4 00001  10000          TRA    1,4                                    MARK0661
01205  0601 60 0 05000  10011    HK02  STO*   Y0(2)        K(I) STORAGE              MARK0662
01206  0241 00 0 01246  10001          FDP    HK12                                   MARK0663
01207  0131 00 0 00000  10000          XCA                                           MARK0664
01210  0300 60 0 04400  10011    HK06  FAD*   Y0                                     MARK0665
01211  0601 60 0 03000  10011          STO*   Y            Y0 + K1/2, K2/2, K3       MARK0666
01212  0020 00 0 01154  10001          TRA    HK03                                   MARK0667
01213  0601 00 0 00204  10001    HK04  STO    TEMP+2                                 MARK0668
01214  0131 00 0 00000  10000          XCA                                           MARK0669
01215  0260 00 0 01246  10001          FMP    HK12                                   MARK0670
01216  0300 60 0 05000  10011          FAD*   Y0(2)                                  MARK0671

BINARY CARD (NOT PUNCHED)
01217  0601 60 0 05000  10011          STO*   Y0(2)        K1 + 2 K2                 MARK0672
01220  0500 00 0 00204  10001          CLA    TEMP+2                                 MARK0673
01221  0020 00 0 01206  10001          TRA    HK02+1                                 MARK0674
01222  0601 00 0 00204  10001    HK05  STO    TEMP+2                                 MARK0675
01223  0131 00 0 00000  10000          XCA                                           MARK0676
01224  0260 00 0 01246  10001          FMP    HK12                                   MARK0677
01225  0300 60 0 05000  10011          FAD*   Y0(2)                                  MARK0678
01226  0601 60 0 05000  10011          STO*   Y0(2)        K1 + 2 K2 + T K3          MARK0679
01227  0500 00 0 00204  10001          CLA    TEMP+2                                 MARK0680
01230  0020 00 0 01210  10001          TRA    HK06                                   MARK0681
01231  0300 60 0 05000  10011    HK07  FAD*   Y0(2)                                  MARK0682
01232  0241 00 0 01247  10001          FDP    HK13                                   MARK0683
01233  0131 00 0 00000  10000          XCA                 (K1 + TK2 + TK3 + K4)/6   MARK0684
01234  0300 60 0 04000  10011          FAD*   Y(2)                                   MARK0685
01235  0300 60 0 04400  10011          FAD*   Y0                                     MARK0686
01236  0601 60 0 03000  10011          STO*   Y                                      MARK0687
01237  4600 60 0 04000  10011          STQ*   Y(2)                                   MARK0688
01240  0020 00 0 01154  10001          TRA    HK03                                   MARK0689
01241  0 00000 0 01205  10001                 HK02                                   MARK0690

BINARY CARD (NOT PUNCHED)
01242  0 00000 0 01213  10001                 HK04                                   MARK0691
01243  0 00000 0 01222  10001                 HK05                                   MARK0692
01244  0 00000 0 01231  10001                 HK07                                   MARK0693
01245  001000000000     10000    HK11  OCT    1000000000                             MARK0694
01246  202400000000     10000    HK12  DEC    2.                                     MARK0695
01247  203600000000     10000    HK13  DEC    6.                                     MARK0696
01250  0020 00 0 01257  10001    ADAMS TRA    ADAMS+7                                MARK0697
01251  0020 00 0 00402  10011          TRA    *+2                                    MARK0698
01252  0761 00 0 00000  10000          NOP                                           MARK0699
01253  0774 00 1 00400  10011          AXT    *,1                                    MARK0700
01254  0774 00 2 00400  10011          AXT    *,2                                    MARK0701
01255  0774 00 4 00400  10011          AXT    *,4                                    MARK0702
01256  0020 00 4 00001  10000          TRA    1,4          EXIT                      MARK0703
01257  0634 00 1 01253  10001          SXA    ADAMS+3,1                              MARK0704
01260  0634 00 2 01254  10001          SXA    ADAMS+4,2                              MARK0705
01261  0634 00 4 01255  10001          SXA    ADAMS+5,4                              MARK0706
01262  4520 00 0 00251  10001          NZT    E                                      MARK0707
01263  0020 00 0 00406  10011          TRA    **6                                    MARK0708
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      01264  4520 00 0 01676  10001         NZT    A                                          MARK0709

BINARY CARD (NOT PUNCHED)
      01265  0020 00 0 00404  10011         TRA    **4                                        MARK0710
      01266  0600 00 0 01676  10001         STZ    A                                          MARK0711
      01267  0074 00 4 00414  10001         TSX    ABTR,4                                     MARK0712
      01270  0020 00 0 01127  10001         TRA    GT10+1                                     MARK0713
      01271  0074 00 4 01576  10001         TSX    GAINT,4                                    MARK0714
      01272  0 00000 0 00000  10000         PZE                                               MARK0715
      01273  0500 00 0 01400  10011         CLA    HC                                         MARK0716
      01274  0300 00 0 00240  10001         FAD    T1                                         MARK0717
      01275  0601 00 0 00202  10001         STO    TEMP                                       MARK0718
      01276  0131 00 0 00000  10000         XCA                                               MARK0719
      01277  0300 00 0 00241  10001         FAD    T2                                         MARK0720
      01300  0300 00 0 00202  10001         FAD    TEMP                                       MARK0721
      01301  0601 00 0 00240  10001         STQ    T1                                         MARK0722
      01302  4600 00 0 00241  10001         STQ    T2                                         MARK0723
      01303  0601 60 0 00243  10001         STO*   L(T1)                                      MARK0724
      01304  4600 60 0 00244  10001         STQ*   L(T2)                                      MARK0725
      01305  0522 00 0 00250  10001         XEC    DER1           TO DERIV BOX 1              MARK0726
      01306  4520 00 0 00251  10001         NZT    E                                          MARK0727
      01307  0020 00 0 01337  10001         TRA    RGUP                                       MARK0728

BINARY CARD (NOT PUNCHED)
      01310  0534 00 1 00237  10001         LXA    (N),1                                      MARK0729
      01311  0534 00 2 00230  10001  RGET1  LXA    MP1,2          ERROR TEST 1                MARK0730
      01312  0500 60 2 00273  10001         CLA*   DELX,2         SAVE YN,DELTA N             MARK0731
      01313  0601 60 2 00323  10001         STO*   DELZ,2                                     MARK0732
      01314  2 00001 2 40402  10011         TIX    *-2,2,1                                    MARK0733
      01315  4520 00 0 00251  10001         NZT    E                                          MARK0734
      01316  0020 00 0 00403  10011         TRA    **3                                        MARK0735
      01317  1 77777 2 00401  10011         TXI    **1,2,-1                                   MARK0736
      01320  7 00000 2 40406  10011         TXL    *-6,2,0                                    MARK0737
      01321  0500 60 0 04400  10011         CLA*   Y0                                         MARK0738
      01322  0601 60 0 00324  10001         STO*   YN                                         MARK0739
      01323  0500 60 0 05000  10011         CLA*   Y0(2)                                      MARK0740
      01324  0601 60 0 00325  10001         STO*   YN2                                        MARK0741
      01325  2 00001 1 01311  10001         TIX    RGET1,1,1                                  MARK0742
      01326  0500 00 0 03372  10001         CLA    RFIX1                                      MARK0743
      01327  0601 00 0 02000  10011         STO    NI                                         MARK0744
      01330  0534 00 2 00230  10001         LXA    MP1,2                                      MARK0745
      01331  0500 00 2 01655  10001         CLA    GCOFP,2                                    MARK0746
      01332  0241 00 2 01666  10001         FDP    GCOFC-1,2                                  MARK0747

BINARY CARD (NOT PUNCHED)
      01333  0131 00 0 00000  10000         XCA                                               MARK0748
      01334  0760 00 0 00003  10000         SSP                                               MARK0749
      01335  0601 00 0 01670  10001         STO    RGA                                        MARK0750
      01336  0020 00 0 01337  10001         TRA    RGUP                                       MARK0751
      01337  0074 00 4 02603  10001  RGUP   TSX    UPDAT,4                                    MARK0752
      01340  0500 00 0 02000  10011         CLA    NI                                         MARK0753
      01341  4100 00 0 01356  10001         TNZ    GND1           TO CORRECT                  MARK0754
      01342  0534 00 1 00237  10001  GND    LXA    (N),1                                      MARK0755
      01343  0500 60 0 03000  10011         CLA*   Y                                          MARK0756
      01344  0601 60 0 04400  10011         STO*   Y0                                         MARK0757
      01345  0500 60 0 04000  10011         CLA*   Y(2)                                       MARK0758
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      01346  0601 60 0 05000  10011        STO*    Y0(2)                              MARK0759
      01347  2 00001 1 40404  10011        TIX     *-4,1,1                            MARK0760
      01350  4520 00 0 00251  10001        NZT     E                                  MARK0761
      01351  0020 00 0 00404  10011        TRA     *+4                                MARK0762
      01352  4520 00 0 01676  10001        NZT     A                                  MARK0763
      01353  0020 00 0 00402  10011        TRA     *+2                                MARK0764
      01354  0074 00 4 03024  10001        TSX     X2,0,4                             MARK0765
      01355  0020 00 0 01253  10001        TRA     ADAMS+3        TO EXIT             MARK0766

BINARY CARD (NOT PUNCHED)
      01356  0601 00 0 00205  10001   GND1 STO     TEMP+3                             MARK0767
      01357  4120 00 0 00403  10011        TMI     *+3                                MARK0768
      01360  0500 00 0 01252  10001        CLA     ADAMS+2                            MARK0769
      01361  0020 00 0 00402  10011        TRA     *+2                                MARK0770
      01362  0500 00 0 01251  10001        CLA     ADAMS+1                            MARK0771
      01363  0601 00 0 01543  10001        STO     GFRK2                              MARK0772
      01364  0600 00 0 03023  10001        STZ     GZP                                MARK0773
      01365  0074 00 4 03007  10001        TSX     PUTB,4                             MARK0774
      01366  0534 00 1 00237  10001        LXA     (N),1                              MARK0775
      01367  0600 60 0 04400  10011        STZ*    Y0                                 MARK0776
      01370  0600 60 0 05000  10011        STZ*    Y0(2)                              MARK0777
      01371  2 00001 1 40402  10011        TIX     *-2,1,1                            MARK0778
      01372  0074 00 4 01576  10001        TSX     GAINT,4        CORRECT             MARK0779
      01373  000000077777     10000        OCT     77777                              MARK0780
      01374  4754 00 0 00000  10000        PXD     0,0                                MARK0781
      01375  0534 00 1 00230  10001        LXA     MP1,1                              MARK0782
      01376  0300 00 1 01667  10001        FAD     GCOFC,1        SUM M+1 COEFF       MARK0783
      01377  2 00001 1 40401  10011        TIX     *-1,1,1                            MARK0784
      01400  0601 00 0 00256  10001        STO     GSIGM                              MARK0785

BINARY CARD (NOT PUNCHED)
      01401  0522 00 0 00247  10001   GLP  XEC     DER2           TIME UNCH D.R.      MARK0786
      01402  0534 00 4 00230  10001        LXA     MP1,4                              MARK0787
      01403  0534 00 1 00237  10001        LXA     (N),1                              MARK0788
      01404  0500 60 0 03400  10011        CLA*    YDOT                               MARK0789
      01405  0302 60 4 00273  10001        FSB*    DELX,4                             MARK0790
      01406  0302 60 0 05000  10011        FSB*    Y0(2)                              MARK0791
      01407  0601 60 0 04400  10011        STO*    Y0                                 MARK0792
      01410  0300 60 0 05000  10011        FAD*    Y0(2)                              MARK0793
      01411  0601 60 0 05000  10011        STO*    Y0(2)                              MARK0794
      01412  2 00001 1 40406  10011        TIX     *-6,1,1                            MARK0795
      01413  4520 00 0 00251  10001        NZT     E              AEC TEST 2          MARK0796
      01414  0020 00 0 01543  10001        TRA     GFRK2                              MARK0797
      01415  0600 00 0 10000  10011        STZ     RGERR          ERROR TEST 2        MARK0798
      01416  0600 00 0 01673  10001        STZ     RGYPC                              MARK0799
      01417  0534 00 1 00237  10001        LXA     (N),1                              MARK0800
      01420  0500 60 0 03000  10011   RG1  CLA*    Y                                  MARK0801
      01421  0760 00 0 00003  10000        SSP                                        MARK0802
      01422  0340 00 0 07400  10011        CAS     YCLOW                              MARK0803
      01423  0020 00 0 00403  10011        TRA     *+3                                MARK0804

BINARY CARD (NOT PUNCHED)
      01424  0020 00 0 00402  10011        TRA     *+2                                MARK0805
      01425  0500 00 0 07400  10011        CLA     YCLOW                              MARK0806
      01426  0601 00 0 01672  10001        STO     RGDI                               MARK0807
      01427  0074 00 4 01677  10001        TSX     RGMAX,4                            MARK0808
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      01430  0760 00 0 00003  10000        SSP                                      MARK0809
      01431  0241 00 0 01672  10001        FDP     RGDI                             MARK0810
      01432  0131 00 0 00000  10000        XCA                                      MARK0811
      01433  0340 00 0 01673  10001        CAS     RGYPC                            MARK0812
      01434  0020 00 0 00403  10011        TRA     *+3                              MARK0813
      01435  0020 00 0 00402  10011        TRA     *+2                              MARK0814
      01436  0500 00 0 01673  10001        CLA     RGYPC                            MARK0815
      01437  0601 00 0 01673  10001        STO     RGYPC                            MARK0816
      01440  0241 00 0 01670  10001        FDP     RGA                              MARK0817
      01441  0500 00 0 10000  10011        CLA     RGERR                            MARK0818
      01442  0040 00 0 00402  10011        TLQ     *+2                              MARK0819
      01443  4600 00 0 10000  10011        STQ     RGERR                            MARK0820
      01444  2 00001 1 01420  10001        TIX     RG1,1,1                          MARK0821
      01445  0500 00 0 10000  10011        CLA     RGERR                            MARK0822
      01446  0340 00 0 06000  10011        CAS     ELBAR                            MARK0823

BINARY CARD (NOT PUNCHED)
      01447  0020 00 0 01463  10001        TRA     RG3                              MARK0824
      01450  0020 00 0 00401  10011        TRA     *+1                              MARK0825
      01451  0520 00 0 00252  10001        ZET     HD                               MARK0826
      01452  0020 00 0 01543  10001        TRA     GFRK2                            MARK0827
      01453  0500 00 0 01400  10011        CLA     HC                               MARK0828
      01454  0300 00 0 01400  10011        FAD     HC                               MARK0829
      01455  0340 00 0 06400  10011        CAS     HMAXT                            MARK0830
      01456  0020 00 0 01543  10001        TRA     GFRK2                            MARK0831
      01457  0020 00 0 01543  10001        TRA     GFRK2                            MARK0832
      01460  0500 00 0 00400  10011        CLA     *                                MARK0833
      01461  0601 00 0 01676  10001        STO     A                                MARK0834
      01462  0020 00 0 01543  10001        TRA     GFRK2                            MARK0835
      01463  0500 00 0 10000  10011   RG3  CLA     RGERR                            MARK0836
      01464  0340 00 0 05400  10011        CAS     EUBAR                            MARK0837
      01465  0020 00 0 01470  10001        TRA     RGX+2                            MARK0838
      01466  0020 00 0 01543  10001        TRA     GFRK2                            MARK0839
      01467  0020 00 0 01543  10001        TRA     GFRK2                            MARK0840
      01470  0560 00 0 01400  10011 RGX+2  LDQ     HC                               MARK0841
      01471  0260 00 0 01653  10001        FMP     GCOFP-2        0.5 DELTA T       MARK0842

BINARY CARD (NOT PUNCHED)
      01472  0340 00 0 07000  10011        CAS     HMINT                            MARK0843
      01473  0020 00 0 00403  10011        TRA     *+3                              MARK0844
      01474  0020 00 0 01543  10001        TRA     GFRK2                            MARK0845
      01475  0020 00 0 01543  10001        TRA     GFRK2                            MARK0846
      01476  0500 00 0 03372  10001        CLA     RFIX1          HALVE             MARK0847
      01477  0601 00 0 00253  10001        STO     NH                               MARK0848
      01500  0502 00 0 01400  10011        CLS     HC                               MARK0849
      01501  0300 00 0 00240  10001        FAD     T1                               MARK0850
      01502  0601 00 0 00202  10001        STO     TEMP                             MARK0851
      01503  0131 00 0 00000  10000        XCA                                      MARK0852
      01504  0300 00 0 00241  10001        FAD     T2                               MARK0853
      01505  0300 00 0 00202  10001        FAD     TEMP                             MARK0854
      01506  0601 00 0 00240  10001        STO     T1                               MARK0855
      01507  4600 00 0 00241  10001        STQ     T2                               MARK0856
      01510  0601 60 0 00243  10001        STO*    L(T1)                            MARK0857
      01511  4600 60 0 00244  10001        STQ*    L(T2)          RESTORE TN        MARK0858
      01512  0534 00 1 00237  10001        LXA     (N),1                            MARK0859
      01513  0774 00 4 00002  10000   RG4  AXT     2,4                              MARK0860
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      01514  0534 00 2 00230  10001         LXA   MP1,2                                    MARK0861

BINARY CARD (NOT PUNCHED)
      01515  0500 60 2 00323  10001         CLA*  DELZ,2                                   MARK0862
      01516  0601 60 2 00273  10001         STO*  DELX,2                                   MARK0863
      01517  6 00001 4 00402  10011         TNX   *+2,4,1                                  MARK0864
      01520  0601 60 0 03400  10011         STO*  YDOT                                     MARK0865
      01521  2 00001 2 40404  10011         TIX   *-4,2,1                                  MARK0866
      01522  1 77777 2 00401  10011         TXI   *+1,2,-1                                 MARK0867
      01523  7 00000 2 40406  10011         TXL   *-6,2,0                                  MARK0868
      01524  0500 60 0 00324  10001         CLA*  YN                                       MARK0869
      01525  0601 60 0 04400  10011         STO*  Y0                                       MARK0870
      01526  0601 60 0 03000  10011         STO*  Y                                        MARK0871
      01527  0500 60 0 00325  10001         CLA*  YN2                                      MARK0872
      01530  0601 60 0 05000  10011         STO*  Y0(2)                                    MARK0873
      01531  0601 60 0 04000  10011         STO*  Y(2)                                     MARK0874
      01532  2 00001 1 01513  10001         TIX   RG4,1,1                                  MARK0875
      01533  0522 00 0 00216  10001         XEC   AEOS                                     MARK0876
      01534  0600 00 0 00234  10001         STZ   ND                                       MARK0877
      01535  0600 00 0 00252  10001         STZ   HD                                       MARK0878
      01536  0500 00 0 03157  10001         CLA   RBIG                                     MARK0879
      01537  0601 00 0 00221  10001         STO   TRG2                                     MARK0880

BINARY CARD (NOT PUNCHED)
      01540  0074 00 4 00414  10001         TSX   ARTB,4      FIND NEW TMIN                MARK0881
      01541  0020 00 0 01127  10001         TRA   GT10+1      ERROR RETURN                 MARK0882
      01542  0020 00 0 00752  10001         TRA   GT2+1                                    MARK0883
      01543  0761 00 0 00000  10000   GFRK2 NOP                                            MARK0884
      01544  0534 00 2 00205  10001         LXA   TEMP+3,2                                 MARK0885
      01545  1 77777 2 00401  10011         TXI   *+1,2,-1                                 MARK0886
      01546  0634 00 2 00205  10001         SXA   TEMP+3,2                                 MARK0887
      01547  3 00000 2 00402  10011         TXH   *+2,2,0                                  MARK0888
      01550  0020 00 0 01565  10001         TRA   GADN-2                                   MARK0889
      01551  0534 00 1 00257  10001         LXA   (N),1       FORM NEXT ITERATE            MARK0890
      01552  0560 00 0 01400  10011         LDQ   HC                                       MARK0891
      01553  0260 00 0 00256  10001         FMP   GSIGM                                    MARK0892
      01554  0601 00 0 00203  10001         STO   TEMP+1                                   MARK0893
      01555  0560 00 0 00203  10001         LDQ   TEMP+1                                   MARK0894
      01556  0260 60 0 04400  10011         FMP*  Y0                                       MARK0895
      01557  0300 60 0 04000  10011         FAD*  Y(2)                                     MARK0896
      01560  0300 60 0 03000  10011         FAD*  Y                                        MARK0897
      01561  0601 60 0 03000  10011         STO*  Y                                        MARK0898
      01562  4600 60 0 04000  10011         STQ*  Y(2)                                     MARK0899

BINARY CARD (NOT PUNCHED)
      01563  2 00001 1 40406  10011         TIX   *-6,1,1                                  MARK0900
      01564  0020 00 0 01401  10001         TRA   GLP                                      MARK0901
      01565  0761 00 0 00000  10000         NOP                                            MARK0902
      01566  0534 00 2 00230  10001         LXA   MP1,2       FIXED ITERATIONS END         MARK0903
      01567  0534 00 1 00257  10001   GADN  LXA   (N),1
      01570  0500 60 0 05000  10011         CLA*  Y0(2)                                    MARK0905
      01571  0300 60 2 00273  10001         FAD*  DELX,2                                   MARK0906
      01572  0601 60 2 00273  10001         STO*  DELX,2                                   MARK0907
      01573  2 00001 1 40403  10011         TIX   *-3,1,1                                  MARK0908
      01574  2 00001 2 40405  10011         TIX   *-5,2,1     DIFF TABLE UPDATED           MARK0909
      01575  0020 00 0 01342  10001         TRA   GND         TO EXIT                      MARK0910
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    01576  0020 00 0 00407  10011  GAINT TRA  *+7          PREDICTOR-CORRECTOR SR   MARK0911
    01577  0 00000 0 01655  10001        PZE  GCOFP        CALL SFQ                 MARK0912
    01600  0 00000 0 01607  10001        PZE  GCOFC        TSX GAINT,4              MARK0913
    01601  0774 00 1 00400  10011        AXT  *,1          PZE K                    MARK0914
    01602  0774 00 2 00400  10011        AXT  *,2          NOR RET                  MARK0915
    01603  0774 00 4 00400  10011        AXT  *,4          IF K=0,PREDICT           MARK0916
    01604  0020 00 4 00002  10000        TRA  2,4          IF K NOT 0,CORRECT       MARK0917
    01605  0634 00 1 01601  10001        SXA  GAINT+3,1                             MARK0918

BINARY CARD (NOT PUNCHED)
    01606  0634 00 2 01602  10001        SXA  GAINT+4,2                             MARK0919
    01607  0634 00 4 01603  10001        SXA  GAINT+5,4                             MARK0920
    01610  0500 00 4 00001  10000        CLA  1,4                                   MARK0921
    01611  0100 00 0 00403  10011        TZE  *+3                                   MARK0922
    01612  0500 00 0 01600  10001        CLA  GAINT+2                               MARK0923
    01613  0020 00 0 00402  10011        TRA  *+2                                   MARK0924
    01614  0500 00 0 01577  10001        CLA  GAINT+1                               MARK0925
    01615  0621 00 0 00405  10011        STA  *+5                                   MARK0926
    01616  0534 00 1 00237  10001        LXA  (N),1                                 MARK0927
    01617  0534 00 2 00230  10001        LXA  MP1,2                                 MARK0928
    01620  0774 00 4 00001  10000        AXT  1,4                                   MARK0929
    01621  0600 00 0 00202  10001        STZ  TEMP                                  MARK0930
    01622  0560 00 4 00400  10011        LDQ  *,4                                   MARK0931
    01623  0260 60 2 00273  10001        FMP* DELX,2                                MARK0932
    01624  0300 00 0 00202  10001        FAD  TEMP                                  MARK0933
    01625  0601 00 0 00202  10001        STO  TEMP                                  MARK0934
    01626  1 00001 4 00401  10011        TXI  *+1,4,1                               MARK0935
    01627  2 00001 2 40405  10011        TIX  *-5,2,1                               MARK0936
    01630  0131 00 0 00000  10000        XCA                                        MARK0937

BINARY CARD (NOT PUNCHED)
    01631  0260 00 0 01400  10011        FMP  HC                                    MARK0938
    01632  0300 60 0 03000  10011        FAD* Y                                     MARK0939
    01633  0601 00 0 00202  10001        STO  TEMP                                  MARK0940
    01634  0131 00 0 00000  10000        XCA                                        MARK0941
    01635  0300 60 0 04000  10011        FAD* Y(2)                                  MARK0942
    01636  0300 00 0 00202  10001        FAD  TEMP                                  MARK0943
    01637  0601 60 0 03000  10011        STO* Y                                     MARK0944
    01640  4600 60 0 04000  10011        STQ* Y(2)                                  MARK0945
    01641  2 00001 1 40422  10011        TIX  *-18,1,1                              MARK0946
    01642  0020 00 0 01601  10001        TRA  GAINT+3      TO EXIT                  MARK0947
    01643  177445756155     10000        DEC  0.2870754484                          MARK0948
    01644  177455743603     10000        DEC  0.294868003                           MARK0949
    01645  177467415215     10000        DEC  0.304224539                           MARK0950
    01646  177503125041     10000        DEC  0.315591936                           MARK0951
    01647  177521616162     10000        DEC  0.329861111                           MARK0952
    01650  177544764477     10000        DEC  0.348611111                           MARK0953
    01651  177600000000     10000        DEC  0.375                                 MARK0954
    01652  177652525252     10000        DEC  0.416666666                           MARK0955
    01653  200400000000     10000        DEC  0.5                                   MARK0956

BINARY CARD (NOT PUNCHED)
    01654  201400000000     10000        DEC  1.0                                   MARK0957
    01655  572402477054     10000  GCOFP DEC  -0.0078925542                         MARK0958
    01656  572462460502     10000        DEC  -0.0093565362                         MARK0959
    01657  572564371174     10000        DEC  -0.0113673950                         MARK0960
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01660  572723445067   10000          DEC  -0.0142691795                                         MARK0961
01661  573463146315   10000          DEC  -0.1875E-1                                            MARK0962
01662  573660266026   10000          DEC  -0.2638888888E-1                                      MARK0963
01663  574525252525   10000          DEC  -0.4166666666E-1                                      MARK0964
01664  575525252525   10000          DEC  -0.8333333333E-1                                      MARK0965
01665  600400000000   10000          DEC  -0.5                                                  MARK0966
01666  201400000000   10000          DEC  1.0                                                   MARK0967
01667  0 00000 0 00000 10000   GCOFC PZE                                                        MARK0968
01670  0 00000 0 00000 10000     RGA PZE                          COEFF. FOR ERROR DETER.       MARK0969
01671  0 00000 0 00000 10000   RGERR PZE                          F(N+1)                        MARK0970
01672  0 00000 0 00000 10000    RGDI PZE                      /D(T)/                            MARK0971
01673  200000000003   00001    RGYPC BSS  3                                                     MARK0972
01676  0 00000 0 00000 10000       A PZE  0                   FLAG WORD FOR TURNING ON DOUBLING(AEC)   MARK0973
01677  0634 00 4 01726 10001   RGMAX SXA  RGMX,4                                                MARK0974
01700  0634 00 2 01727 10001         SXA  RGMX+1,2                                              MARK0975

BINARY CARD (NOT PUNCHED)
01701  0534 00 2 00230 10001         LXA  MP1,2                                                 MARK0976
01702  0774 00 4 00001 10000         AXT  1,4                                                   MARK0977
01703  0600 00 0 01674 10001         STZ  RGYPC+1                                               MARK0978
01704  0560 00 4 01667 10001         LDQ  GCOFC,4                                               MARK0979
01705  0260 60 2 00273 10001         FMP* DELX,2                                                MARK0980
01706  0300 00 0 01674 10001         FAD  RGYPC+1                                               MARK0981
01707  0601 00 0 01674 10001         STO  RGYPC+1                                               MARK0982
01710  1 00001 4 00401 10011         TXI  *+1,4,1                                               MARK0983
01711  2 00001 2 40405 10011         TIX  *-5,2,1                                               MARK0984
01712  0534 00 2 00230 10001         LXA  MP1,2                                                 MARK0985
01713  0774 00 4 00001 10000         AXT  1,4                                                   MARK0986
01714  0600 00 0 01675 10001         STZ  RGYPC+2                                               MARK0987
01715  0560 00 4 01655 10001         LDQ  GCOFP,4                                               MARK0988
01716  0260 60 2 00323 10001         FMP* DELZ,2                                                MARK0989
01717  0300 00 0 01675 10001         FAD  RGYPC+2                                               MARK0990
01720  0601 00 0 01675 10001         STO  RGYPC+2                                               MARK0991
01721  1 00001 4 00401 10011         TXI  *+1,4,1                                               MARK0992
01722  2 00001 2 40405 10011         TIX  *-5,2,1                                               MARK0993
01723  0302 00 0 01674 10001         FSB  RGYPC+1                                               MARK0994

BINARY CARD (NOT PUNCHED)
01724  0131 00 0 00000 10000         XCA                                                        MARK0995
01725  0260 00 0 01400 10011         FMP  HC                                                    MARK0996
01726  0774 00 4 00000 10000    RGMX AXT  0,4                                                   MARK0997
01727  0774 00 2 00000 10000         AXT  0,2                                                   MARK0998
01730  0020 00 4 00001 10000         TRA  1,4                                                   MARK0999
01731  0634 00 1 01770 10001    FLAG SXA  OOP,1                   SAVE INDEX 1                  MARK1000
01732  0634 00 2 01771 10001         SXA  OUCH,2                  SAVE INDEX 2                  MARK1001
01733  0634 00 4 01765 10001         SXA  OUT,4                   SAVE INDEX 4                  MARK1002
01734  0774 00 2 00062 10000         AXT  OMAR,2                                                MARK1003
01735  0534 00 4 00231 10001         LXA  I4,4                    INDEX FROM TSX MARK,4         MARK1004
01736  0600 00 0 02031 10001         STZ  ORGY                                                  MARK1005
01737  0500 00 4 00004 10000    OMNI CLA  4,4                                                   MARK1006
01740  0100 00 0 01765 10001         TZE  OUT                     LAST TRIGGER                  MARK1007
01741  4120 00 0 01761 10001         TMI  OMER                    IGNORE NEGATIVE TRIGGERS      MARK1008
01742  4737 00 1 00000 10000         PDC  ,1                      ADDRESS IN INDEX1             MARK1009
01743  7 00000 1 01761 10001         TXL  OMER,1,0                IGNORE TIME STOPS             MARK1010
01744  0500 00 1 00000 10000         CLA  0,1                     YSUBJ                         MARK1011
01745  0302 60 4 00005 10000         FSB* 5,4                                                   MARK1012
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        01746  0601 00 0 00202  10001         STO   TEMP                                         MARK1013

BINARY CARD (NOT PUNCHED)
        01747  4120 00 0 01773  10001         TMI   OREY       SIGN OF DIFFERENCE TEST          MARK1014
        01750  0500 60 0 02032  10001         CLA*  L          YSUBJ-ZSUBJ AT TI                MARK1015
        01751  0120 00 0 01775  10001         TPL   OINK       IF SAME SIGN IGNORE              MARK1016
        01752  0500 00 0 00202  10001   OZONE CLA   TEMP                                        MARK1017
        01753  0601 60 0 02033  10001         STO*  R          RJEWJ FOR FLAG                   MARK1018
        01754  0601 60 0 02034  10001         STO*  W                                           MARK1019
        01755  0500 00 0 01751  10001         CLA   FLAG                                        MARK1020
        01756  0625 00 0 02051  10001         STI   ORGY       TEST FOR FLAG RETURN             MARK1021
        01757  0625 00 4 00004  10000   ODEN  STI   4,4        FLAG                             MARK1022
        01760  1 77777 2 00401  10011         TXI   *+1,2,-1                                    MARK1023
        01761  1 77776 4 00401  10011   OAFR  TXI   *+1,4,-2                                    MARK1024
        01762  3 00000 2 01737  10001         TXH   OMNI,2,0                                    MARK1025
        01763  0534 00 4 00231  10001         LXA   I4,4       ERROR RETURN FOR TOO MANY        MARK1026
        01764  0020 00 4 00003  10000         TRA   3,4                                         MARK1027
        01765  0774 00 4 00000  10000   OUT   AXT   ,4         DEPENDENT VARIABLE STOPS         MARK1028
        01766  0520 00 0 02051  10001         ZET   ORGY       IF ZERO                          MARK1029
        01767  1 77777 4 01770  10001         TXI   OOP,4,-1                                    MARK1030
        01770  0774 00 1 00000  10000   OOP   AXT   ,1         OTHERWISE NORMAL                 MARK1031
        01771  0774 00 2 00000  10000   OOCH  AXT   ,2                                          MARK1032

BINARY CARD (NOT PUNCHED)
        01772  0020 00 4 00001  10000         TRA   1,4                                         MARK1033
        01773  0500 60 0 02032  10001   OREY  CLA*  L          YSUBJ-ZSUBJ AT TI.               MARK1034
        01774  0120 00 0 01752  10001         TPL   OZONE      SET FLAG IF SIGN NOT EQUAL       MARK1035
        01775  0500 00 0 00400  10011   OINK  CLA   *          OTHERWISE CLEAR TAG              MARK1036
        01776  0020 00 0 01757  10001         TRA   ODEN       AND CONTINUE                     MARK1037
        01777  0634 00 4 02025  10001   SET   SXA   ORIT,4     SAVE INDEX 4                     MARK1038
        02000  0634 00 2 02027  10001         SXA   OOZE,2     SAVE INDEX 2                     MARK1039
        02001  0634 00 1 02026  10001         SXA   ODE,1      SAVE INDEX 1                     MARK1040
        02002  0534 00 4 00231  10001         LXA   14,4                                        MARK1041
        02003  0774 00 2 00062  10000         AXT   OMAR,2                                      MARK1042
        02004  0500 00 0 00240  10001         CLA   T1                                          MARK1043
        02005  0601 00 0 00176  10001         STO   TL                                          MARK1044
        02006  0500 00 0 00241  10001         CLA   T2         OR                               MARK1045
        02007  0601 00 0 00177  10001         STO   TL2        OTHERWISE                        MARK1046
        02010  0500 00 4 00004  10000   OVER  CLA   4,4                                         MARK1047
        02011  0100 00 0 02025  10001         TZE   ORIT       LAST TRIGGER                     MARK1048
        02012  4120 00 0 02021  10001         TMI   OMEN       IGNORE NEGATIVE TRIGGER          MARK1049
        02013  4737 00 1 00000  10000         PDC   ,1                                          MARK1050
        02014  7 00000 1 02021  10001         TXL   OMEN,1,0   IGNORE TIME STOPS                MARK1051

BINARY CARD (NOT PUNCHED)
        02015  0500 00 1 00000  10000         CLA   0,1        YSUBJ                            MARK1052
        02016  0302 60 4 00005  10000         FSB*  5,4                                         MARK1053
        02017  0601 60 0 02032  10001         STO*  L          YSUBJ-ZSUBJ                      MARK1054
        02020  1 77777 2 00401  10011         TXI   *+1,2,-1                                    MARK1055
        02021  1 77776 4 02022  10001   OMEN  TXI   OPINE,4,-2                                  MARK1056
        02022  3 00000 2 02010  10001   OPINE TXH   OVER,2,0                                    MARK1057
        02023  0534 00 4 00231  10001         LXA   14,4       ERROR RETURN FOR TOO MANY        MARK1058
        02024  1 77776 4 02026  10001         TXI   ODE,4,-2   DEPENDENT VARIABLE STOPS         MARK1059
        02025  0774 00 4 00000  10000   ORIT  AXT   ,4                                          MARK1060
        02026  0774 00 1 00000  10000   ODE   AXT   ,1                                          MARK1061
        02027  0774 00 2 00000  10000   OOZE  AXT   ,2                                          MARK1062
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     02030  0020 00 4 00001  10000        TRA   1,4                                          MARK1063
     02031  0 00000 0 00000  10000  ORGY  PZE                    TAG STORAGE                 MARK1064
     02032  0 00000 2 02117  10001     L  PZE   LTAB+OMAR,2                                  MARK1065
     02033  0 00000 2 02201  10001     R  PZE   RTAB+OMAR,2                                  MARK1066
     02034  0 00000 2 02263  10001     W  PZE   WTAB+OMAR,2                                  MARK1067
     02035  200000000062     00001  LTAB  BSS   OMAR                                         MARK1069
     02117  200000000062     00001  RTAB  BSS   OMAR                                         MARK1070
     02201  200000000062     00001  WTAB  BSS   OMAR                                         MARK1071

BINARY CARD (NOT PUNCHED)
     02263  0634 00 4 02376  10001  SRCH  SXA   OROY,4           SAVE INDFX 4                MARK1072
     02264  0634 00 2 02431  10001        SXA   OVAL,2           SAVE INDEX 2                MARK1073
     02265  0634 00 1 02377  10001        SXA   ORB,1            SAVE INDFX 1                MARK1074
     02266  0500 00 0 02440  10001        CLA   ORESE                                        MARK1075
     02267  0601 00 0 02436  10001        STO   OGEE             HM=BTG                      MARK1076
     02270  0601 00 0 02437  10001        STO   HP                                           MARK1077
     02271  0534 00 4 00251  10001        LXA   14,4             INDEX FROM TSX MARK,4       MARK1078
     02272  0774 00 2 00062  10000        AXT   OMAR,2                                       MARK1079
     02273  0500 00 4 00004  10000  ONSET CLA   4,4                                          MARK1080
     02274  0100 00 0 02376  10001        TZE   OROY             LAST TRIGGER                MARK1081
     02275  4120 00 0 02372  10001        TMI   OMIT             OMIT NEGATIVF TRIGGERS      MARK1082
     02276  4737 00 1 00000  10000        PDC   0,1                                          MARK1083
     02277  7 00000 1 02372  10001        TXL   OMIT,1,0         OMIT INDFPENDENT STOPS      MARK1084
     02300  0625 00 0 02031  10001        STT   ORGY                                         MARK1085
     02301  4520 00 0 02031  10001        NZT   ORGY             TEST WORD                   MARK1086
     02302  0020 00 0 02371  10001        TRA   ODOR             FQUAL ZERO                  MARK1087
     02303  0500 00 1 00000  10000        CLA   0,1              NOT FQUAL ZERO              MARK1088
     02304  0302 60 4 00005  10000        FSB*  5,4                                          MARK1089
     02305  0601 60 0 02034  10001        STO*  W                WSUBJ=YSUBJ-ZSUBJ           MARK1090

BINARY CARD (NOT PUNCHED)
     02306  0302 60 0 02032  10001        FSB*  L                                            MARK1091
     02307  0601 00 0 00204  10001        STO   TEMP+2                                       MARK1092
     02310  4500 60 0 02034  10001        CAL*  W                                            MARK1093
     02311  0322 60 0 02032  10001        ERA*  L                                            MARK1094
     02312  4760 00 0 00001  10000        PBT                                                MARK1095
     02313  0020 00 0 02343  10001        TRA   REACH            EQUAL SIGN SGN WJ=SGN LJ    MARK1096
     02314  0634 00 4 02321  10001        SXA   OVARY,4          OPPOSITE IN SIGN            MARK1097
     02315  0634 00 2 02320  10001        SXA   OVARY-1,2                                    MARK1098
     02316  0074 00 4 02716  10001        TSX   DSUB,4                                       MARK1099
     02317  0 00240 0 00176  10101        PZE   TL,,T1                                       MARK1100
     02320  0774 00 2 00000  10000        AXT   **,2                                         MARK1101
     02321  0774 00 4 00000  10000  OVARY AXT   **,4                                         MARK1102
     02322  0241 00 0 00204  10001        FDP   TEMP+2           (TL-T)/(WJ-LJ)              MARK1103
     02323  0260 60 0 02034  10001        FMP*  W                                            MARK1104
     02324  0601 00 0 00202  10001        STO   TEMP        R                                MARK1105
     02325  0500 00 0 02436  10001        CLA   OGEE             HM                          MARK1106
     02326  0560 00 0 00202  10001        LDQ   TEMP             P                           MARK1107
     02327  0040 00 0 00402  10011        TLQ   *+2                                          MARK1108
     02330  0020 00 0 02332  10001        TRA   RSTOR                                        MARK1109

BINARY CARD (NOT PUNCHED)
     02331  4600 00 0 02436  10001        STQ   OGEE             R LESS THAN HM              MARK1110
     02332  0500 00 0 00202  10001  RSTOR CLA   TEMP                                         MARK1111
     02333  0760 00 0 00003  10000        SSP                                                MARK1112
     02334  0302 00 0 00175  10001        FSB   DELU                                         MARK1113
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      02335  0120 00 0 02340  10001        TPL   OCCUR                                MARK1114
      02336  0500 00 0 02441  10001        CLA   OFT                                  MARK1115
      02337  0020 00 0 02341  10001        TRA   ONION                                MARK1116
      02340  0500 00 0 02377  10001  OCCUR CLA   ORB                                  MARK1117
      02341  0625 00 4 00004  10000  ONION STT   4,4                                  MARK1118
      02342  0020 00 0 02371  10001        TRA   ODOR                                 MARK1119
      02343  4500 60 0 02034  10001  REACH CAL*  W                                    MARK1120
      02344  0322 60 0 02033  10001        ERA*  R                                    MARK1121
      02345  4760 00 0 00001  10000        PBT                                        MARK1122
      02346  0020 00 0 02367  10001        TRA   RFLAG           SGN WJ=SGN RJ        MARK1123
      02347  0500 60 0 02034  10001        CLA*  W                                    MARK1124
      02350  0302 60 0 02033  10001        FSB*  R                                    MARK1125
      02351  0601 00 0 00204  10001        STO   TEMP+2          WJ-RJ                MARK1126
      02352  0634 00 2 00404  10011        SXA   *+4,2                                MARK1127
      02353  0634 00 4 00404  10011        SXA   *+4,4                                MARK1128

BINARY CARD (NOT PUNCHED)
      02354  0074 00 4 02716  10001        TSX   DSUB,4                               MARK1129
      02355  0 00240 0 00200  10101        PZE   TR,,T1                               MARK1130
      02356  0774 00 2 00000  10000        AXT   **,2                                 MARK1131
      02357  0774 00 4 00000  10000        AXT   **,4                                 MARK1132
      02360  0241 00 0 00204  10001        FDP   TEMP+2          (TR-T)/(WJ-RJ)       MARK1133
      02361  0260 60 0 02034  10001        FMP*  W                                    MARK1134
      02362  0601 00 0 00202  10001        STO   TEMP                                 MARK1135
      02363  0560 00 0 02437  10001        LDQ   HP                                   MARK1136
      02364  0040 00 0 02332  10001        TLQ   RSTOR                                MARK1137
      02365  0601 00 0 02437  10001        STO   HP                                   MARK1138
      02366  0020 00 0 02332  10001        TRA   RSTOR                                MARK1139
      02367  0500 00 0 00400  10011  RFLAG CLA   *                                    MARK1140
      02370  0625 00 4 00004  10000        STT   4,4                                  MARK1141
      02371  1 77777 2 00401  10011  ODOR  TXI   *+1,2,-1                             MARK1142
      02372  1 77776 4 00401  10011  OMIT  TXI   *+1,4,-2                             MARK1143
      02373  3 00000 2 02273  10001        TXH   ONSET,2,0                            MARK1144
      02374  0534 00 4 00231  10001        LXA   14,4                                 MARK1145
      02375  0020 00 4 00003  10000        TRA   3,4     FRROR RETURN (TOO MANY DFPEND. VAR TRIMARK1146
      02376  0774 00 4 00000  10000  OBOY  AXT   **,4                                 MARK1147

BINARY CARD (NOT PUNCHED)
      02377  0774 00 1 00000  10000  ORB   AXT   **,1                                 MARK1148
      02400  0500 00 0 02436  10001        CLA   OGEE                                 MARK1149
      02401  0302 00 0 02440  10001        FSB   ORESE                                MARK1150
      02402  4100 00 0 02415  10001        TNZ   RSTRJ                                MARK1151
      02403  0774 00 2 00062  10000        AXT   OMAR,2                               MARK1152
      02404  0500 60 0 02034  10001        CLA*  W                                    MARK1153
      02405  0601 60 0 02032  10001        STO*  L               LJ=WJ                MARK1154
      02406  2 00001 2 40402  10011        TIX   *-2,2,1                              MARK1155
      02407  0500 00 0 00240  10001        CLA   T1                                   MARK1156
      02410  0560 00 0 00241  10001        LDQ   I2                                   MARK1157
      02411  0601 00 0 00176  10001        STO   TL                                   MARK1158
      02412  4600 00 0 00177  10001        STQ   TL2                                  MARK1159
      02413  0500 00 0 02437  10001        CLA   HP                                   MARK1160
      02414  0020 00 0 02426  10001        TRA   RSTOT                                MARK1161
      02415  0774 00 2 00062  10000  RSTRJ AXT   OMAR,2                               MARK1162
      02416  0500 60 0 02034  10001        CLA*  W                                    MARK1163
      02417  0601 60 0 02033  10001        STO*  R               RJ=WJ                MARK1164
      02420  2 00001 2 40402  10011        TIX   *-2,2,1                              MARK1165
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      02421  0500 00 0 00240  10001         CLA    T1                                           MARK1166

BINARY CARD (NOT PUNCHED)
      02422  0560 00 0 00241  10001         LDQ    T2                                           MARK1167
      02423  0601 00 0 00200  10001         STO    TR                                           MARK1168
      02424  4600 00 0 00201  10001         STQ    TR2                                          MARK1169
      02425  0500 00 0 02436  10001         CLA    OGEE                                         MARK1170
      02426  0601 00 0 00253  10001  RSTOT  STO    HIC                                          MARK1171
      02427  0760 00 0 00003  10000         SSP                                                 MARK1172
      02430  0560 00 0 00175  10001         LDQ    DELU                                         MARK1173
      02431  0774 00 2 00000  10000  OVAL   AXT    **,2                                         MARK1174
      02432  0040 00 0 00402  10011         TLQ    *+2                                          MARK1175
      02433  0020 00 4 00001  10000         TRA    1,4                                          MARK1176
      02434  0500 00 0 00253  10001         CLA    HIC                                          MARK1177
      02435  0020 00 4 00002  10000         TRA    2,4                                          MARK1178
      02436  0 00000 0 00000  10000  OGEE   PZE    HM                                           MARK1179
      02437  0 00000 0 00000  10000  HP     PZE                                                 MARK1180
      02440  377777777777     10000  OBESE  OCT    377777777777                                 MARK1181
      02441  0 00000 5 00000  10000  OFT    PZE    .5                                           MARK1182
                                                   INTERPOLATION ROUTINE FOR ADAMS-MOULTON (MARK) MARK1183
                                                   TSX INTRP,4                                  MARK1184
                                                   NORMAL RETURN                                MARK1185
      02442  0634 00 4 02551  10001  INTRP  SXA    RICH,4           ENTER                       MARK1186
      02443  0634 00 1 02552  10001         SXA    RICH+1,1                                     MARK1187
      02444  0634 00 2 02553  10001         SXA    RICH+2,2                                     MARK1188

BINARY CARD (NOT PUNCHED)
      02445  0074 00 4 02716  10001         TSX    DSUB,4                                       MARK1189
      02446  0 00240 0 02400  10111         PZE    TGO,,T1                                      MARK1190
      02447  0601 00 0 02575  10001         STO    RIMU-1           HC(MU)                      MARK1191
      02450  0241 00 0 01400  10011         FDP    HC                                           MARK1192
      02451  4600 00 0 02576  10001         STQ    RIM              MU                          MARK1193
      02452  0534 00 2 02463  10001         LXA    RLOC1+3,2        IR2=2                       MARK1194
      02453  0534 00 4 00232  10001         LXA    M,4              IR4=M                       MARK1195
      02454  0500 00 0 02620  10001         CLA    RIB                                          MARK1196
      02455  0601 00 0 02621  10001         STO    RIC                                          MARK1197
      02456  0601 00 0 02622  10001         STO    RFACT                                        MARK1198
      02457  0601 00 4 02574  10001         STO    RIMU-2,4                                     MARK1199
      02460  0500 00 0 02621  10001  RLOC1  CLA    RIC                                          MARK1200
      02461  0300 00 0 02620  10001         FAD    RIB                                          MARK1201
      02462  0601 00 0 02621  10001         STO    RIC                                          MARK1202
      02463  0131 00 0 00002  10000         XCA    2                                            MARK1203
      02464  0260 00 0 02622  10001         FMP    RFACT                                        MARK1204
      02465  0601 00 0 02622  10001         STO    RFACT                                        MARK1205
      02466  0500 00 0 02576  10001         CLA    RIM           MU,MU-1,.....                  MARK1206
      02467  0302 00 0 02620  10001         FSB    RIB                                          MARK1207

BINARY CARD (NOT PUNCHED)
      02470  0601 00 0 02576  10001         STO    RIM                                          MARK1208
      02471  0131 00 0 00001  10000  RZERO  XCA    1                                            MARK1209
      02472  0260 00 4 02574  10001         FMP    RIMU-2,4                                     MARK1210
      02473  0601 00 4 02575  10001         STO    RIMU-1,4                                     MARK1211
      02474  0241 00 0 02622  10001         FDP    RFACT                                        MARK1212
      02475  0131 00 0 00000  10000         XCA                                                 MARK1213
      02476  6 00001 2 02501  10001         TNX    RLOC2,2,1                                    MARK1214
      02477  0760 00 0 00002  10000         CHS                                                 MARK1215
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      02500  0020 00 0 02502  10001          TRA   RLOC2+1                                       MARK1216
      02501  1 00001 2 02502  10001   RLOC2  TXI   RLOC2+1,2,1                                   MARK1217
      02502  0601 00 4 02642  10001          STO   RAJ,4              ASUBJ J=1,...,M            MARK1218
      02503  2 00001 4 02460  10001          TIX   RLOC1,4,1                                     MARK1219
      02504  0534 00 4 00232  10001          LXA   M,4                                           MARK1220
      02505  4754 00 4 00000  10000   RLOC3  PXD   0,4                                           MARK1221
      02506  4734 00 2 00000  10000          PDX   0,2                                           MARK1222
      02507  0534 00 1 00232  10001          LXA   M,1                                           MARK1223
      02510  0500 00 2 02620  10001          CLA   RIB,2                                         MARK1224
      02511  0601 00 0 02601  10001          STO   RSUMC                                         MARK1225
      02512  0560 00 1 02642  10001          LDQ   RAJ,1                                         MARK1226

BINARY CARD (NOT PUNCHED)
      02513  0260 00 2 02621  10001          FMP   RIB+1,2                                       MARK1227
      02514  0300 00 0 02601  10001          FAD   RSUMC                                         MARK1228
      02515  0601 00 0 02601  10001          STO   RSUMC                                         MARK1229
      02516  1 77777 1 00401  10011          TXI   *+1,1,-1                                      MARK1230
      02517  2 00001 2 02512  10001          TIX   RLOC3+5,2,1                                   MARK1231
      02520  0601 00 4 02601  10001          STO   RICJ,4                                        MARK1232
      02521  2 00001 4 02505  10001          TIX   RLOC3,4,1                                     MARK1233
      02522  0534 00 1 00237  10001          LXA   (N),1              NO. OF. EQUAT.             MARK1234
      02523  0534 00 2 00232  10001          LXA   M,2                                           MARK1235
      02524  0534 00 4 02471  10001          LXA   RZERO,4                                       MARK1236
      02525  0600 00 0 02602  10001          STZ   RSUMD                                         MARK1237
      02526  0560 60 2 00273  10001   RLOC4  LDQ*  DELX,2             DIFFERENCES                MARK1238
      02527  0260 00 4 02601  10001          FMP   RICJ,4                                        MARK1239
      02530  0300 00 0 02602  10001          FAD   RSUMD                                         MARK1240
      02531  0601 00 0 02602  10001          STO   RSUMD                                         MARK1241
      02532  1 00001 4 00401  10011          TXI   *+1,4,1                                       MARK1242
      02533  2 00001 2 02526  10001          TIX   RLOC4,2,1                                     MARK1243
      02534  0300 60 4 00273  10001          FAD*  DELX,4                                        MARK1244
      02535  0131 00 0 00000  10000          XCA                                                 MARK1245

BINARY CARD (NOT PUNCHED)
      02536  0260 00 0 02575  10001          FMP   RIMU-1                                        MARK1246
      02537  0601 00 0 02600  10001          STO   RSAVE                                         MARK1247
      02540  0500 60 0 05000  10011          CLA*  Y0(2)                                         MARK1248
      02541  0302 00 0 02600  10001          FSB   RSAVE                                         MARK1249
      02542  0300 60 0 04400  10011          FAD*  Y0                                            MARK1250
      02543  0601 60 0 03000  10011          STO*  Y                                             MARK1251
      02544  4600 60 0 04000  10011          STQ*  Y(2)                                          MARK1252
      02545  2 00001 1 02523  10001          TIX   RLOC4-3,1,1                                   MARK1253
      02546  0634 00 1 03023  10001          SXA   GZP,1                                         MARK1254
      02547  0522 00 0 00250  10001          XEC   DER1                                          MARK1255
      02550  0522 00 0 00216  10001          XEC   AEQS                                          MARK1256
      02551  0774 00 4 00000  10000   R1CH   AXT   **,4                                          MARK1257
      02552  0774 00 1 00000  10000          AXT   **,1                                          MARK1258
      02553  0774 00 2 00000  10000          AXT   **,2                                          MARK1259
      02554  0020 00 4 00001  10000          TRA   1,4                EXIT                       MARK1260
      02576  20000000021      00001   R1MU   BES   17                                            MARK1261
      02576  0 00000 0 00000  10000   RIM    PZE                      MU(MU-1)(MU-2)...(MU-I)    MARK1262
      02577  0 00000 0 00000  10000   RMP1   PZE                      M+1                        MARK1263
      02600  0 00000 0 00000  10000   RSAVE  PZE                                                 MARK1264

BINARY CARD (NOT PUNCHED)
      02601  570765462703     10000          DEC   -0.382689955E-2    B15                        MARK1265
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 02602  571424166250   10000          DEC   -0.421495223E-2      B14            MARK1266
 02603  571462426633   10000          DEC   -0.467749840E-2      B13            MARK1267
 02604  571527142211   10000          DEC   -0.523669325E-2      B12            MARK1268
 02605  571604172262   10000          DEC   -0.592405641E-2      B11            MARK1269
 02606  571674557257   10000          DEC   -0.67858499RE-2      B10            MARK1270
 02607  572402477053   10000          DEC   -0.7892554012E-2     B9             MARK1271
 02610  572462460505   10000          DEC   -0.935653659E-2      B8             MARK1272
 02611  572564371164   10000          DEC   -.1136739417E-1   R7                MARK1273
 02612  572723445072   10000          DEC   -0.1426917989E-1  R6                MARK1274
 02613  573463146315   10000          DEC   -0.01875          R5                MARK1275
 02614  573660266027   10000          DEC   -0.0263888889     R4                MARK1276
 02615  574525252525   10000          DEC   -0.0416666667     R3                MARK1277
 02616  575525252525   10000          DEC   -0.0833333333     R2                MARK1278
 02617  600400000000   10000          DEC   -0.5              R1                MARK1279
 02620  201400000000   10000    RIB   DEC   1.0               R0 BSUBJ VALUES (0-10)  MARK1280
 02621  0 00000 0 00000 10000   RIC   PZE                                       MARK1281
 02622  0 00000 0 00000 10000   RFACT PZE                     FACTORIALS        MARK1282
 02642  200000000017   00001    RAJ   BES   15                A SUB J           MARK1283

BINARY CARD (NOT PUNCHED)
 02661  200000000017   00001    RICJ  BES   15                C SUB J           MARK1284
 02661  0 00000 0 00000 10000   RSUMC PZE                                       MARK1285
 02662  0 00000 0 00000 10000   RSUMD PZE                                       MARK1286
 02663  0634 00 1 02711 10001   UPDAT SXA   HU03,1                              MARK1287
 02664  0634 00 2 02712 10001         SXA   HU04,2                              MARK1288
 02665  0534 00 1 00257 10001         LXA   (N),1             C(XR1)=(N)        MARK1289
 02666  0534 00 2 00250 10001         LXA   MP1,2             C(XR2)=M+1        MARK1290
 02667  0520 00 0 00251 10001         ZET   E                                   MARK1291
 02670  1 00001 2 00401 10011         TXI   **+1,2,1          BUMP XR2 IF E=1   MARK1292
 02671  0634 00 2 02676 10001         SXA   HU01,2                              MARK1293
 02672  0500 00 0 02714 10001         CLA   HU05                                MARK1294
 02673  0400 00 0 00251 10001         ADD   E                                   MARK1295
 02674  0621 00 0 02703 10001         STA   HU06              ADDRESS IS DELX + E  MARK1296
 02675  0621 00 0 02706 10001         STA   HU07                                MARK1297
 02676  0774 00 2 00000 10000   HU01  AXT   **,2                                MARK1298
 02677  0500 60 0 03400 10011         CLA*  YDOT                                MARK1299
 02700  0601 00 0 00202 10001         STO   TEMP                                MARK1300
 02701  0500 00 0 00202 10001   HU02  CLA   TEMP                                MARK1301
 02702  0601 00 0 00203 10001         STO   TEMP+1                              MARK1302

BINARY CARD (NOT PUNCHED)
 02703  0302 60 2 00000 10000   HU06  FSB*  **,2                                MARK1303
 02704  0601 00 0 00202 10001         STO   TEMP                                MARK1304
 02705  0500 00 0 00203 10001         CLA   TEMP+1                              MARK1305
 02706  0601 60 2 00000 10000   HU07  STO*  **,2                                MARK1306
 02707  2 00001 2 02701 10001         TIX   HU02,2,1          INNER LOOP, DO M+ 1+E  MARK1307
 02710  2 00001 1 02676 10001         TIX   HU01,1,1          OUTER LOOP, DO (N)  MARK1308
 02711  0774 00 1 00000 10000   HU03  AXT   **,1                                MARK1309
 02712  0774 00 2 00000 10000   HU04  AXT   **,2                                MARK1310
 02713  0020 00 4 00001 10000         TRA   1,4                                 MARK1311
 02714  0 00000 0 00273 10001   HU05  PZE   DELX                                MARK1312
 02715  0020 00 0 02724 10001   DADD  TRA   DSUB+6            TSX DADD-DSUB,4   MARK1313
 02716  0020 00 0 02721 10001   DSUB  TRA   DSUB+3            PZE L(A1),0,L(B1)  MARK1314
 02717  0 00000 0 00000 10000         PZE                                       MARK1315
 02720  0 00000 0 00000 10000         PZE                                       MARK1316
 02721  0500 00 0 02716 10001         CLA   DSUB                                MARK1317
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      02722  0601 00 0 02720  10001             STO    DSUB+2                                     MARK1318
      02723  0020 00 0 00402  10011             TRA    *+2                                        MARK1319
      02724  0600 00 0 02720  10001             STZ    DSUB+2                                     MARK1320
      02725  0500 00 4 00001  10000             CLA    1,4                                        MARK1321

BINARY CARD (NOT PUNCHED)
      02726  0601 00 0 02717  10001             STO    DSUB+1                                     MARK1322
      02727  4535 00 1 02717  10001             LDC    DSUB+1,1                                   MARK1323
      02730  0535 00 2 02717  10001             LAC    DSUB+1,2                                   MARK1324
      02731  0500 00 1 00001  10000             CLA    1,1                                        MARK1325
      02732  0520 00 0 02720  10001             ZET    DSUB+2                                     MARK1326
      02733  0760 00 0 00002  10000             CHS                                               MARK1327
      02734  0300 00 2 00001  10000             FAD    1,2                                        MARK1328
      02735  0601 00 0 00202  10001             STO    TEMP                                       MARK1329
      02736  0500 00 1 00000  10000             CLA    0,1                                        MARK1330
      02737  0520 00 0 02720  10001             ZET    DSUB+2                                     MARK1331
      02740  0760 00 0 00002  10000             CHS                                               MARK1332
      02741  0300 00 2 00000  10000             FAD    0,2                                        MARK1333
      02742  0601 00 0 00203  10001             STO    TEMP+1                                     MARK1334
      02743  0131 00 0 00000  10000             XCA                                               MARK1335
      02744  0300 00 0 00202  10001             FAD    TEMP                                       MARK1336
      02745  0300 00 0 00203  10001             FAD    TEMP+1                                     MARK1337
      02746  0020 00 4 00002  10000             TRA    2,4                                        MARK1338
      02747  0634 00 4 03003  10001      START  SXA    GRT1,4      TEST TRANSITION FROM RK TO AM  MARK1339
      02750  0500 00 0 00235  10001             CLA    H                                          MARK1340

BINARY CARD (NOT PUNCHED)
      02751  0300 00 0 00240  10001             FAD    T1                                         MARK1341
      02752  0601 00 0 00202  10001             STO    TEMP                                       MARK1342
      02753  0131 00 0 00000  10000             XCA                                               MARK1343
      02754  0300 00 0 00241  10001             FAD    T2                                         MARK1344
      02755  0300 00 0 00202  10001             FAD    TEMP                                       MARK1345
      02756  0601 00 0 00221  10001             STO    TRG2                                       MARK1346
      02757  4600 00 0 00222  10001             STQ    TRG2+1                                     MARK1347
      02760  0074 00 4 02603  10001             TSX    UPDAT,4                                    MARK1348
      02761  0500 00 0 00167  10001             CLA    J                                          MARK1349
      02762  0400 00 0 03005  10001             ADD    START+30                                   MARK1350
      02763  0601 00 0 00167  10001             STO    J                                          MARK1351
      02764  0520 00 0 00251  10001             ZET    E                                          MARK1352
      02765  0402 00 0 03005  10001             SUB    START+30                                   MARK1353
      02766  0402 00 0 00230  10001             SUB    MP1                                        MARK1354
      02767  4100 00 0 03003  10001             TNZ    GRT1                                       MARK1355
      02770  0500 00 0 03006  10001             CLA    START+31                                   MARK1356
      02771  0601 00 0 00221  10001             STO    TRG2                                       MARK1357
      02772  0500 00 0 00235  10001             CLA    H                                          MARK1358
      02773  0601 00 0 01400  10011             STO    HC                                         MARK1359

BINARY CARD (NOT PUNCHED)
      02774  0534 00 1 00237  10001             LXA    (N),1                                      MARK1360
      02775  0500 60 0 03000  10011             CLA*   Y                                          MARK1361
      02776  0560 60 0 04000  10011             LDQ*   Y(2)                                       MARK1362
      02777  0601 60 0 04400  10011             STO*   Y0                                         MARK1363
      03000  4600 60 0 05000  10011             STQ*   Y0(2)                                      MARK1364
      03001  2 00001 1 40404  10011             TIX    *-4,1,1                                    MARK1365
      03002  0020 00 0 00751  10001             TRA    GTO         TO AMC                         MARK1366
      03003  0774 00 4 00000  10000      GRT1   AXT    **,4                                       MARK1367
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03004  0020 00 4 00001  10000          TRA   1,4                                        MARK1368
03005  000000000001     10000          DEC   1                                          MARK1369
03006  377777777777     10000          OCT   377777777777                               MARK1370
03007  0634 00 4 03021  10001    PUTB  SXA   PTB1,4                                     MARK1371
03010  0534 00 1 00237  10001          LXA   (N),1                                      MARK1372
03011  0500 60 0 04400  10011          CLA*  Y0          RESET DEP VAR BANK            MARK1373
03012  0601 60 0 03000  10011          STO*  Y           FROM SECONDARY BANK           MARK1374
03013  0500 60 0 05000  10011          CLA*  Y0(2)                                      MARK1375
03014  0601 60 0 04000  10011          STO*  Y(2)                                       MARK1376
03015  2 00001 1 40404  10011          TIX   *-4,1,1                                    MARK1377
03016  0520 00 0 03023  10001          ZET   GZP                                        MARK1378

BINARY CARD (NOT PUNCHED)
03017  0522 00 0 00250  10001          XEC   DER1                                       MARK1379
03020  0600 00 0 03023  10001          STZ   GZP                                        MARK1380
03021  0774 00 4 00000  10000    PTB1  AXT   **,4                                       MARK1381
03022  0020 00 4 00001  10000          TRA   1,4                                        MARK1382
03023  0 00000 0 00000  10000    GZP   PZE                                              MARK1383
                                 * SUBR FOR DOUBLING (MARK)                             MARK1384
                                 *     TSX   X2.0                                       MARK1385
                                 *     NORMAL RETURN                                    MARK1386
03024  0634 00 4 03072  10001    X2.0  SXA   RX2.0,4                                    MARK1387
03025  0634 00 1 03073  10001          SXA   RX2.0+1,1                                  MARK1388
03026  0634 00 2 03074  10001          SXA   RX2.0+2,2                                  MARK1389
03027  0500 00 0 00232  10001          CLA   M                                          MARK1390
03030  0520 00 0 00251  10001          ZET   E                                          MARK1391
03031  0500 00 0 00230  10001          CLA   MP1                                        MARK1392
03032  0361 00 0 03154  10001          ACL   RMAG                                       MARK1393
03033  0300 00 0 03154  10001          FAD   RMAG                                       MARK1394
03034  0131 00 0 00000  10000          XCA                                              MARK1395
03035  0260 00 0 01400  10011          FMP   HC                                         MARK1396
03036  0601 00 0 00202  10001          STO   TEMP                                       MARK1397
03037  0131 00 0 00000  10000          XCA                                              MARK1398
03040  0300 00 0 00241  10001          FAD   T2                                         MARK1399
03041  0601 00 0 00203  10001          STO   TEMP+1                                     MARK1400

BINARY CARD (NOT PUNCHED)
03042  0500 00 0 00240  10001          CLA   T1                                         MARK1401
03043  0300 00 0 00202  10001          FAD   TEMP                                       MARK1402
03044  0601 00 0 00202  10001          STO   TEMP                                       MARK1403
03045  0131 00 0 00000  10000          XCA                                              MARK1404
03046  0300 00 0 00203  10001          FAD   TEMP+1                                     MARK1405
03047  0300 00 0 00202  10001          FAD   TEMP                                       MARK1406
03050  0601 00 0 00221  10001          STO   TRG2                                       MARK1407
03051  4600 00 0 00222  10001          STQ   TRG2+1                                     MARK1408
03052  0500 00 0 03155  10001          CLA   RALF2                                      MARK1409
03053  0621 00 0 00214  10001          STA   TRIGO                                      MARK1410
03054  0500 00 0 03154  10001          CLA   RMAG                                       MARK1411
03055  0601 00 0 00252  10001          STO   HD                                         MARK1412
03056  0074 00 4 03414  10001          TSX   RSUM,4                                     MARK1413
03057  0534 00 1 00237  10001          LXA   (N),1                                      MARK1414
03060  0534 00 2 00230  10001    RAGS  LXA   MP1,2                                      MARK1415
03061  0500 60 2 00273  10001    ROGS  CLA*  DELX,2                                     MARK1416
03062  0601 60 2 00307  10001          STO*  DELY,2                                     MARK1417
03063  2 00001 2 03061  10001          TIX   ROGS,2,1                                   MARK1418
03064  4520 00 0 00251  10001          NZT   E                                          MARK1419
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     ASSEMBLED TEXT.

BINARY CARD (NOT PUNCHED)
  03065  0020 00 0 03070  10001        TRA RIGS                                                     MARK1420
  03066  1 77777 2 00401  10011        TXI     *+1,2,-1                                             MARK1421
  03067  7 00000 2 03061  10001        TXL     ROGS,2,0                                             MARK1422
  03070  2 00001 1 03060  10001  RIGS  TTX     RAGS,1,1                                             MARK1423
  03071  0074 00 4 03373  10001        TSX     RUPDA,4                                              MARK1424
  03072  0774 00 4 00000  10000  RX2.0 AXT     **,4                                                 MARK1425
  03073  0774 00 1 00000  10000        AXT     **,1                                                 MARK1426
  03074  0774 00 2 00000  10000        AXT     **,2                                                 MARK1427
  03075  0020 00 4 00001  10000        TRA     1,4                                                  MARK1428
  03076  0634 00 4 03072  10001  RISK  SXA     RX2.0,4                                              MARK1429
  03077  0634 00 1 03073  10001        SXA     RX2.0+1,1                                            MARK1430
  03100  0634 00 2 03074  10001        SXA     RX2.0+2,2                                            MARK1431
  03101  0600 00 0 00252  10001        STZ     HD                                                   MARK1432
  03102  0560 00 0 01400  10011        LDQ     HC                                                   MARK1433
  03103  0260 00 0 03156  10001        FMP     RDUBL                                                MARK1434
  03104  0601 00 0 01400  10011        STO     HC                  HC=2.0HC                         MARK1435
  03105  0500 00 0 03157  10001        CLA     RBIG                                                 MARK1436
  03106  0601 00 0 00221  10001        STO     TRG2                                                 MARK1437
  03107  0074 00 4 03414  10001        TSX     RSUM,4                                               MARK1438

BINARY CARD (NOT PUNCHED)
  03110  0534 00 1 00237  10001        LXA     (N),1                                                MARK1439
  03111  0500 00 0 03160  10001  RIN1  CLA     RAD1                                                 MARK1440
  03112  0621 00 0 03124  10001        STA     RIN2                                                 MARK1441
  03113  0534 00 2 00230  10001        LXA     MP1,2                                                MARK1442
  03114  4634 00 2 03130  10001        SXD     RIN3,2                                               MARK1443
  03115  4634 00 2 03131  10001        SXD     RIN4,2                                               MARK1444
  03116  0774 00 2 00001  10000        AXT     1,2
  03117  0774 00 4 00001  10000        AXT     1,4
  03120  4520 00 0 00251  10001        NZT     E
  03121  0020 00 0 03124  10001        TRA     RIN2
  03122  0774 00 2 00000  10000        AXT     0,2
  03123  0774 00 4 00000  10000        AXT     0,4
  03124  0500 60 2 00307  10001  RIN2  CLA*    DELY,2                                               MARK1448
  03125  0601 60 4 00307  10001        STO*    DELY,4                                               MARK1449
  03126  1 00002 2 00401  10011        TXI     *+1,2,2                                              MARK1450
  03127  1 00001 4 00401  10011        TXI     *+1,4,1                                              MARK1451
  03130  7 00000 2 03124  10001  RIN3  TXL     RIN2,2,0                                             MARK1452
  03131  7 00000 4 03133  10001  RIN4  TXL     ROCK,4,0                                             MARK1453
  03132  0020 00 0 03151  10001        TRA     ROLL                                                 MARK1454

BINARY CARD (NOT PUNCHED)
  03133  0500 00 0 03161  10001  ROCK  CLA     RAD2                                                 MARK1455
  03134  0621 00 0 03124  10001        STA     RIN2                                                 MARK1456
  03135  0774 00 2 00002  10000        AXT     2,2                                                  MARK1457
  03136  0500 00 0 00232  10001        CLA     M                                                    MARK1458
  03137  0760 00 0 00001  10000        LBT                                                          MARK1459
  03140  0020 00 0 03144  10001        TRA     RIN5                                                 MARK1460
  03141  0520 00 0 00251  10001        ZET     E                   M ODD                            MARK1461
  03142  0774 00 2 00002  10000        AXT     2,2                 ERR CONTROL(SKIP FOR NO ERR CONTROL MARK1462
  03143  0020 00 0 03124  10001        TRA     RIN2                                                 MARK1463
  03144  0774 00 2 00003  10000  RIN5  AXT     3,2                 M EVEN                           MARK1464
  03145  4520 00 0 00251  10001        NZT     E                                                    MARK1465
  03146  0020 00 0 03124  10001        TRA     RIN2                NO ERROR CONTROL                 MARK1466
  03147  0774 00 2 00001  10000        AXT     1,2                                                  MARK1467
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      03150  0020 00 0 03124  10001         TRA    RIN2               ERROR CONTROL      MARK1468
      03151  2 00001 1 03111  10001   ROLL  TIX    RIN1,1,1                              MARK1469
      03152  0074 00 4 03373  10001         TSX    RUPDA,4                               MARK1470
      03153  0020 00 0 03072  10001         TRA    RX2+0                                 MARK1471
      03154  233000000000     10000   RMAG  OCT    233000000000                          MARK1472
      03155  0074 00 4 03076  10001   RALF2 TSX    RISK,4                                MARK1473

BINARY CARD (NOT PUNCHED)                                                                MARK1474
      03156  202400000000     10000   RDOBL DEC    2.0                                   MARK1475
      03157  377777777777     10000   RBIG  OCT    377777777777                          MARK1476
      03160  0 00000 0 00307  10001   RAD1  PZE    DFLY                                  MARK1477
      03161  0 00000 0 00273  10001   RAD2  PZE    DELX                                  MARK1478
                                    * SUBR FOR HALVING(MARK)                             MARK1479
                                    *       TSX    X.50,4                                MARK1480
                                    *       NORMAL RETURN                                MARK1481
      03162  0634 00 4 03346  10001   X.50  SXA    RX.5,4                                MARK1482
      03163  0634 00 1 03347  10001         SXA    RX.5+1,1                              MARK1483
      03164  0634 00 2 03350  10001         SXA    RX.5+2,2                              MARK1484
      03165  0600 00 0 00234  10001         STZ    ND                                    MARK1485
      03166  0600 00 0 00252  10001         STZ    HD                                    MARK1486
      03167  0500 00 0 03157  10001         CLA    RBIG                                  MARK1487
      03170  0601 00 0 00221  10001         STO    TRG2                                  MARK1488
      03171  0560 00 0 01400  10011         LDQ    HC                                    MARK1489
      03172  0260 00 0 03353  10001         FMP    R0.5                                  MARK1490
      03173  0601 00 0 01400  10011         STO    HC                                    MARK1491
      03174  0500 00 0 00232  10001         CLA    M                                     MARK1492
      03175  0520 00 0 00251  10001         ZET    E                                     MARK1493
      03176  0500 00 0 00230  10001         CLA    MP1                                   MARK1494
      03177  0361 00 0 03352  10001         ACL    RMAGN                                 MARK1495
      03200  0300 00 0 03352  10001         FAD    RMAGN

BINARY CARD (NOT PUNCHED)                                                                MARK1496
      03201  0601 00 0 03355  10001         STO    RFLOM                                 MARK1497
      03202  0601 00 0 03366  10001         STO    RFACM-1                               MARK1498
      03203  0302 00 0 03354  10001         FSB    RFLO1                                 MARK1499
      03204  0601 00 0 03365  10001         STO    RFACM-2                               MARK1500
      03205  0534 00 2 00232  10001         LXA    M,2                                   MARK1501
      03206  0520 00 0 00251  10001         ZET    E                                     MARK1502
      03207  0534 00 2 00230  10001         LXA    MP1,2                                 MARK1503
      03210  1 77776 2 03211  10001         TXI    RNTR5,2,-2                            MARK1504
      03211  0560 00 0 03306  10001   RNTR5 LDQ    RFACM-1                               MARK1505
      03212  0260 00 0 03305  10001         FMP    RFACM-2                               MARK1506
      03213  0601 00 0 03366  10001         STO    RFACM-1                               MARK1507
      03214  0500 00 0 03365  10001         CLA    RFACM-2                               MARK1508
      03215  0302 00 0 03354  10001         FSB    RFLO1                                 MARK1509
      03216  0601 00 0 03365  10001         STO    RFACM-2                               MARK1510
      03217  2 00001 2 03211  10001         TIX    RNTR5,2,1                             MARK1511
      03220  0534 00 1 00237  10001         LXA    (N),1                                 MARK1512
      03221  0074 00 4 03414  10001         TSX    RSUM,4                                MARK1513
      03222  0600 00 0 03356  10001   RNTR1 STZ    RN                                    MARK1514
      03223  0600 00 0 03371  10001         STZ    RNPRI

BINARY CARD (NOT PUNCHED)
      03224  0534 00 2 00230  10001         LXA    MP1,2
      03225  0534 00 4 00230  10001         LXA    MP1,4
      03226  0500 00 0 03371  10001   RNTR0 CLA    RNPRI                                 MARK1516
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      03227  0760 00 0 00001  10000         LBT                                              MARK1517
      03230  0020 00 0 03324  10001         TRA    REVEN           N EVEN                    MARK1518
      03231  0600 00 0 03357  10001   RODD  STZ    RK0             N ODD                     MARK1519
      03232  0634 00 2 03320  10001         SXA    RSAV2,2                                   MARK1520
      03233  0634 00 4 03321  10001         SXA    RSAV3,4                                   MARK1521
      03234  0534 00 4 00232  10001         LXA    M,4                                       MARK1522
      03235  4520 00 0 00251  10001         NZT    E                                         MARK1523
      03236  1 77777 4 00401  10011         TXI    *+1,4,-1                                  MARK1524
      03237  0560 00 0 03356  10001         LDQ    RN                                        MARK1525
      03240  0260 00 0 03353  10001         FMP    R0.5                                      MARK1526
      03241  0760 00 0 00002  10000         CHS                                              MARK1527
      03242  0601 00 0 03362  10001         STO    RIDEL-1                                   MARK1528
      03243  0300 00 0 03354  10001         FAD    RFLO1                                     MARK1529
      03244  0601 00 0 03361  10001         STO    RIDEL-2                                   MARK1530
      03245  0300 00 0 03354  10001         FAD    RFLO1                                     MARK1531
      03246  0601 00 0 03360  10001         STO    RIDEL-3                                   MARK1532

BINARY CARD (NOT PUNCHED)
      03247  0600 00 0 03363  10001         STZ    RSUM5                                     MARK1533
      03250  0560 00 0 03361  10001  RNTR3  LDQ    RIDEL-2                                   MARK1534
      03251  0260 00 0 03360  10001         FMP    RIDEL-3                                   MARK1535
      03252  0601 00 0 03361  10001         STO    RIDEL-2                                   MARK1536
      03253  0500 00 0 03360  10001         CLA    RIDEL-3                                   MARK1537
      03254  0300 00 0 03354  10001         FAD    RFLO1                                     MARK1538
      03255  0601 00 0 03360  10001         STO    RIDEL-3                                   MARK1539
      03256  2 00001 4 03250  10001         TIX    RNTR3,4,1                                 MARK1540
      03257  0500 00 0 03361  10001         CLA    RIDEL-2                                   MARK1541
      03260  0241 00 0 03366  10001         FDP    RFACM-1                                   MARK1542
      03261  4600 00 0 03367  10001         STQ    RA0                                       MARK1543
      03262  0534 00 2 00230  10001         LXA    MP1,2                                     MARK1544
      03263  0560 00 0 03367  10001  RNTR2  LDQ    RA0                                       MARK1545
      03264  0260 60 2 00273  10001         FMP*   DELX,2                                    MARK1546
      03265  0300 00 0 03363  10001         FAD    RSUM5                                     MARK1547
      03266  0601 00 0 03363  10001         STO    RSUM5                                     MARK1548
      03267  0500 00 0 03355  10001         CLA    RFLOM                                     MARK1549
      03270  0302 00 0 03357  10001         FSB    RK0                                       MARK1550
      03271  0601 00 0 03365  10001         STO    RFACM-2                                   MARK1551

BINARY CARD (NOT PUNCHED)
      03272  0500 00 0 03362  10001         CLA    RIDEL-1                                   MARK1552
      03273  0300 00 0 03357  10001         FAD    RK0                                       MARK1553
      03274  0601 00 0 03360  10001         STO    RIDEL-3                                   MARK1554
      03275  0300 00 0 03354  10001         FAD    RFLO1                                     MARK1555
      03276  0601 00 0 03361  10001         STO    RIDEL-2                                   MARK1556
      03277  0500 00 0 03357  10001         CLA    RK0                                       MARK1557
      03300  0300 00 0 03354  10001         FAD    RFLO1                                     MARK1558
      03301  0601 00 0 03357  10001         STO    RK0                                       MARK1559
      03302  0560 00 0 03357  10001         LDQ    RK0                                       MARK1560
      03303  0260 00 0 03361  10001         FMP    RIDEL-2                                   MARK1561
      03304  0601 00 0 03370  10001         STO    RTEMP                                     MARK1562
      03305  0560 00 0 03365  10001         LDQ    RFACM-2                                   MARK1563
      03306  0260 00 0 03360  10001         FMP    RIDEL-3                                   MARK1564
      03307  0241 00 0 03370  10001         FDP    RTEMP                                     MARK1565
      03310  0260 00 0 03367  10001         FMP    RA0                                       MARK1566
      03311  0760 00 0 00002  10000         CHS                                              MARK1567
      03312  0601 00 0 03367  10001         STO    RA0                                       MARK1568
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       03313  2 00001 2 03263  10001        TIX   RNTR2,2,1                         MARK1569
       03314  4520 00 0 00251  10001        NZT   E                                 MARK1570

BINARY CARD (NOT PUNCHED)
       03315  0020 00 0 03320  10001        TRA   RSAV2                             MARK1571
       03316  1 77777 2 00401  10011        TXI   *+1,2,-1                          MARK1572
       03317  7 00000 2 03263  10001        TXL   RNTR2,2,0                         MARK1573
       03320  0774 00 2 00000  10000  RSAV2 AXT   **,2                              MARK1574
       03321  0774 00 4 00000  10000  RSAV3 AXT   **,4                              MARK1575
       03322  0500 00 0 03363  10001        CLA   RSUM5                             MARK1576
       03323  0020 00 0 03325  10001        TRA   REVEN+1                           MARK1577
       03324  0500 60 2 00273  10001  REVEN CLA*  DELX,2                            MARK1578
       03325  0601 60 4 00307  10001        STO*  DELY,4                            MARK1579
       03326  0500 00 0 03356  10001        CLA   RN                                MARK1580
       03327  0300 00 0 03354  10001        FAD   RFLO1                             MARK1581
       03330  0601 00 0 03356  10001        STO   RN                                MARK1582
       03331  0500 00 0 03371  10001        CLA   RNPRI                             MARK1583
       03332  0400 00 0 03372  10001        ADD   RFIX1                             MARK1584
       03333  0601 00 0 03371  10001        STO   RNPRI                             MARK1585
       03334  0760 00 0 00001  10000        LBT                                     MARK1586
       03335  0020 00 0 00402  10011        TRA   *+2                               MARK1587
       03336  1 77777 2 00401  10011        TXI   *+1,2,-1                          MARK1588
       03337  2 00001 4 03226  10001        TIX   RNTR0,4,1                         MARK1589

BINARY CARD (NOT PUNCHED)
       03340  4520 00 0 00251  10001        NZT   E                                 MARK1590
       03341  0020 00 0 03344  10001        TRA   RNTR4                             MARK1591
       03342  1 77777 4 00401  10011        TXI   *+1,4,-1                          MARK1592
       03343  7 00000 4 03226  10001        TXL   RNTR0,4,0                         MARK1593
       03344  2 00001 1 03222  10001  RNTR4 TIX   RNTR1,1,1                         MARK1594
       03345  0074 00 4 03373  10001        TSX   RUPDA,4                           MARK1595
       03346  0774 00 4 00000  10000  RX.5  AXT   **,4                              MARK1596
       03347  0774 00 1 00000  10000        AXT   **,1                              MARK1597
       03350  0774 00 2 00000  10000        AXT   **,2                              MARK1598
       03351  0020 00 4 00001  10000        TRA   1,4                               MARK1599
       03352  233000000000     10000  RMAGN OCT   233000000000                      MARK1600
       03353  200400000000     10000  R0.5  DEC   0.5                               MARK1601
       03354  201400000000     10000  RFLO1 DEC   1.0                               MARK1602
       03355  0 00000 0 00000  10000  RFLOM PZE               FLOAT M               MARK1603
       03356  0 00000 0 00000  10000     RN PZE               N                     MARK1604
       03357  0 00000 0 00000  10000    RKU PZE               K                     MARK1605
       03363  200000000003     00001  RIUEL BES   3                                 MARK1606
       03363  0 00000 0 00000  10000  RSUM5 PZE                                     MARK1607
       03367  200000000003     00001  RFACM BES   3                                 MARK1608

BINARY CARD (NOT PUNCHED)
       03367  0 00000 0 00000  10000    RAU PZE                                     MARK1609
       03370  0 00000 0 00000  10000  RTEMP PZE                                     MARK1610
       03371  0 00000 0 00000  10000  RNPRI PZE                                     MARK1611
       03372  0 00000 0 00001  10000  RFIX1 PZE   1                                 MARK1612
       03373  0634 00 4 03410  10001  RUPDA SXA   RUP3,4                            MARK1613
       03374  0634 00 1 03411  10001        SXA   RUP3+1,1                          MARK1614
       03375  0634 00 2 03412  10001        SXA   RUP3+2,2                          MARK1615
       03376  0534 00 2 00230  10001        LXA   MP1,2                             MARK1616
       03377  4634 00 2 03407  10001        SXD   RUP2,2                            MARK1617
       03400  0774 00 2 00000  10000        AXT   0,2                               MARK1618
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   03401  0534 00 1 00237  10001    RUP0 LXA    (N),1                                  MARK1619
   03402  0500 60 2 00307  10001    RUP1 CLA*   DELY,2                                 MARK1620
   03403  0601 60 0 03400  10011         STO*   YDOT                                   MARK1621
   03404  2 00001 1 03402  10001         TIX    RUP1,1,1                               MARK1622
   03405  0074 00 4 02663  10001         TSX    UPDAT,4                                MARK1623
   03406  1 00001 2 03407  10001         TXI    RUP2,2,1                               MARK1624
   03407  7 00000 2 03401  10001    RUP2 TXL    RUP0,2,0                               MARK1625
   03410  0774 00 4 00000  10000    RUP3 AXT    **,4                                   MARK1626
   03411  0774 00 1 00000  10000         AXT    **,1                                   MARK1627

BINARY CARD (NOT PUNCHED)
   03412  0774 00 2 00000  10000         AXT    **,2                                   MARK1628
   03413  0020 00 4 00001  10000         TRA    1,4                                    MARK1629
                                   * SUBR TO OBTAIN DERIVATIVES FROM DIFFERENCES       MARK1630
                                   *     TSX    RSUM,4                                 MARK1631
                                   *     NORMAL RETURN                                 MARK1632
   03414  0634 00 4 03451  10001    RSUM SXA    RIRS,4                                 MARK1633
   03415  0634 00 1 03452  10001         SXA    RIRS+1,1                               MARK1634
   03416  0634 00 2 03453  10001         SXA    RIRS+2,2                               MARK1635
   03417  4520 00 0 00251  10001         NZT    E                                      MARK1636
   03420  0020 00 0 03455  10001         TRA    REQ                                    MARK1637
   03421  0774 00 2 00001  10000         AXT    1,2                                    MARK1638
   03422  0500 00 0 00230  10001         CLA    MP1                                    MARK1639
   03423  0621 00 0 03433  10001         STA    RSUM1                                  MARK1640
   03424  0621 00 0 03435  10001         STA    RSUM2-1                                MARK1641
   03425  0500 00 2 03464  10001    RECH CLA    RADDS,2                                MARK1642
   03426  0621 00 0 03437  10001         STA    RSUM3                                  MARK1643
   03427  0500 00 2 03463  10001         CLA    RADDS-1,2                              MARK1644
   03430  0621 00 0 03440  10001         STA    RSUM4                                  MARK1645
   03431  0621 00 0 03441  10001         STA RSUM7                                     MARK1646
   03432  0534 00 1 00237  10001         LXA    (N),1            IR1=(N)               MARK1647
   03433  0774 00 2 00000  10000    RSUM1 AXT   0,2                                    MARK1648
   03434  4634 00 2 03443  10001         SXD    RSUM6,2                                MARK1649

BINARY CARD (NOT PUNCHED)
   03435  0774 00 4 00000  10000         AXT    0,4                                    MARK1650
   03436  0774 00 2 00001  10000    RSUM2 AXT   1,2                                    MARK1651
   03437  0500 60 2 00272  10001    RSUM3 CLA*  DELX-1,2                               MARK1652
   03440  0302 60 2 00273  10001    RSUM4 FSB*  DELX,2                                 MARK1653
   03441  0601 60 2 00273  10001    RSUM7 STO*  DELX,2                                 MARK1654
   03442  1 00001 2 03443  10001         TXI    RSUM6,2,1                              MARK1655
   03443  7 00000 2 03437  10001    RSUM6 TXL   RSUM3,2,**                             MARK1656
   03444  4534 00 2 03443  10001         LXD    RSUM6,2                                MARK1657
   03445  1 77777 2 00401  10011         TXI    *+1,2,-1                               MARK1658
   03446  4634 00 2 03443  10001         SXD    RSUM6,2                                MARK1659
   03447  2 00001 4 03436  10001         TIX    RSUM2,4,1                              MARK1660
   03450  2 00001 1 03433  10001         TIX    RSUM1,1,1                              MARK1661
   03451  0774 00 4 00000  10000    RIRS AXT    **,4                                   MARK1662
   03452  0774 00 1 00000  10000         AXT    **,1                                   MARK1663
   03453  0774 00 2 00000  10000         AXT    **,2                                   MARK1664
   03454  0020 00 4 00001  10000         TRA    1,4                                    MARK1665
   03455  0500 00 0 00232  10001    REQ  CLA    M                                      MARK1666
   03456  0621 00 0 03433  10001         STA    RSUM1                                  MARK1667
   03457  0621 00 0 03435  10001         STA    RSUM2-1                                MARK1668

BINARY CARD (NOT PUNCHED)
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03460  0774 00 2 00000  10000          AXT     0,2                          MARK1669
03461  0020 00 0 03425  10001          TRA     RECH                         MARK1670
03462  0 00000 0 00274  10001          PZE     DELX+1                       MARK1671
03463  0 00000 0 00273  10001          PZE     DELX                         MARK1672
03464  0 00000 0 00272  10001   RADDS  PZE     DELX-1                       MARK1673
                 00000  01111          END                                  MARK1675
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          MARS                                              02/17/69                  PAGE
       CONTROL DICTIONARY

              $CDICT MARS                                                      MARS0002

BINARY CARD (NOT PUNCHED)
               003465000000             PREFACE    START=0,LENGTH=1845,TYPE=7094,CMPLX=6
               000004000006
               442151626060     MARS    DECK
               003465000000
               442151426060     MARK    REAL       SECT. 2,LOC=0,LENGTH=0
               000000000000
               302360606060     HC      REAL       SECT. 3,LOC=165,LENGTH=0
               000000000165
               453160606060     NI      REAL       SECT. 4,LOC=166,LENGTH=0
               000000000166
               632743466060     TGLO    REAL       SECT. 5,LOC=173,LENGTH=0
               000000000173
               706060606060     Y       REAL       SECT. 6,LOC=223,LENGTH=0
               000000000223
               702446636060     YDOT    REAL       SECT. 7,LOC=224,LENGTH=0
               000000000224
               700102016060     Y121    REAL       SECT. 8,LOC=225,LENGTH=0
               000000000225
               700060606060     Y0      REAL       SECT. 9,LOC=226,LENGTH=0
               000000000226
               700001020160     Y0121   REAL       SECT. 10,LOC=227,LENGTH=0
               000000000227

BINARY CARD (NOT PUNCHED)
               256422215160     EUBAR   REAL       SECT. 11,LOC=326,LENGTH=0
               000000000326
               254322215160     ELBAR   REAL       SECT. 12,LOC=327,LENGTH=0
               000000000327
               304421676360     HMAXT   REAL       SECT. 13,LOC=330,LENGTH=0
               000000000330
               304431456360     HMINT   REAL       SECT. 14,LOC=331,LENGTH=0
               000000000331
               702343466660     YCLOW   REAL       SECT. 15,LOC=332,LENGTH=0
               000000000332
               512725515160     RGERR   REAL       SECT. 16,LOC=1671,LENGTH=0
               000000001671

              $DKEND MARS                                                      MARS0003

NO MESSAGES FOR THIS ASSEMBLY
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REFERENCES TO DEFINED SYMBOLS.

CLASS	SYMBOL	VALUE	REFERENCES
	ABTB	00414	160,637,703,731,776,1114,1267,1540
	ADAMS	01250	144,1000,1250,1257,1260,1261,1355,1360,1362
	ADDR	00334	73,551
	AFOS	00216	2,522,524,530,532,533,655,664,1043,1533,2550
	AFLAG	00220	421,444,656,1055
	AMC	00712	733,1056
	A	01676	142,1264,1266,1352,1461
	ASET	00217	420,443,647,734,1116
	BMIN	00172	423,465,503,635,726
	DADD	02715	
	DELO	00255	
	DELU	00175	157,577,615,626,633,723,746,1014,1015,2334,2430
	DELX	00273	361,1312,1405,1516,1571,1572,1623,1705,2526,2534,2714,3061,3161,3264,3324,3437,3440,3441, 3462,3463,3464
	DELY	00307	371,3062,3124,3125,3160,3325,3402
	DELZ	00323	403,1313,1515,1716
	DER1	00250	43,146,507,1170,1305,2547,3017
	DER2	00247	45,513,1401
	DSUB	02716	714,737,2316,2354,2445,2715,2716,2721,2722,2724,2726,2727,2730,2732,2737
	ELBAR	00327	0,1446
	EPC	00257	
	E	00251	53,61,74,107,112,136,374,1262,1306,1315,1350,1413,2667,2673,2764,3030,3064,3120,3141,3145, 3175,3206,3235,3314,3340,3417
	EUBAR	00326	0,1464
	FLAG	01731	220,1755
	GADN	01567	1550
	GAINT	01576	1271,1372,1605,1606,1607,1612,1614,1642
	GCOFC	01667	1332,1376,1600,1704
	GCOFP	01655	1331,1471,1577,1715
	GFRK2	01543	1363,1414,1452,1456,1457,1462,1466,1467,1474,1475
	GLP	01401	1564
	GND1	01356	1341
	GND	01342	1575
	GRT1	03003	2747,2767
	GSIGM	00256	1400,1553
	GT0	00731	3002
	GT10	01126	732,777,1012,1013,1115,1270,1541
	GT11	01101	1076,1113
	GT12	01122	1107
	GT13	01110	1124
	GT1	00734	724
	GT2	00751	141,145,1542
	GT3	01015	747,1121
	GT4	01034	1027
	GT5	01046	1025,1033
	GT6	01055	1044,1071
	GT8	01072	1060,1101
	GT9	01114	1075
	GZP	03023	1364,2546,3016,3020
	HA01	00573	414
	HA02	00572	415

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HA03      00571   416
HA04      00434   437,445,461,467,472,474,500,504
HA05      00452   447,457
HA06      00470   451,455,456,475
HA07      00473   462
HA08      00525   515
HA09      00534   523,526
HA10      00505   435
HA11      00440   425,450
HA12      00602   417,521
HA13      00603   442,527
HA14      00604
HA16      00542   540
HC        00165   0,71,644,646,662,1006,1134,1152,1273,1453,1454,1470,1500,1552,1631,1725,2450,2773,3035,3102,
                  3104,3171,3173
HD        00252   126,765,1451,1535,3055,3101,3166
HIC       00253   1062,2426,2434
HK01      01145   1174
HK02      01205   1221,1241
HK03      01154   1212,1240
HK04      01213   1242
HK05      01222   1243
HK06      01210   1230
HK07      01231   1244
HK08      01201   1131
HK09      01202   1132
HK10      01203   1133
HK11      01245   1153
HK12      01246   1135,1206,1215,1224
HK13      01247   1232
HMAXI     00330   0,1455
HMINT     00331   0,1472
HP        02437   2270,2363,2365,2413
HR01      00663
HR02      00642   634
HR03      00711   625,632,642
HR04      00616   641
HR05      00666   661
HR07      00667   705
HR08      00705   672
HR09      00706   154,156,612
HR10      00707   671
HR11      00630   640,704
HR12      00660   605
HR13      00710   614
H         00235   70,151,554,607,643,2750,2772
HU01      02676   2671,2710
HU02      02701   2707
HU03      02711   2663
HU04      02712   2664
HU05      02714   2672
HU06      02703   2674
HU07      02706   2675
14        00231   0,1,3,41,163,433,505,630,666,1073,1127,1735,1763,2002,2023,2271,2374
INTRP     02442   1054,1070
J         00167   72,2761,2763
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SYMBOL REFERENCE DATA

	KUTTA	01131	650,663
	L	02032	1750,1773,2017,2306,2311,2405
	LSTRT	00254	62
	LTAB	02035	2032
	L(M)	00242	17,25,31,127,131,133,135,347,543,553,556,562,564,570,762,775
	L(T1)	00243	21,35,64,1036,1050,1065,1156,1157,1162,1164,1175,1303,1510
	L(T2)	00244	23,37,65,1041,1053,1067,1161,1163,1176,1304,1511
	MARK	00000	0
	MP1	00230	344,366,400,1311,1330,1375,1402,1514,1566,1617,1701,1712,2666,2766,3031,3060,3113,3176,3207, 3224,3225,3262,3376,3422
	M	00232	26,77,342,2453,2504,2507,2523,3027,3136,3174,3205,3234,3455
	ND	00234	125,565,566,763,771,773,1534,3165
	NH	00233	124,557,560,752,756,760,1477
	NI	00166	0,1327,1340
	N	00236	32,101,106,114,115,336,364,376
	OBESE	02440	2266,2401
	OBEY	01773	1747
	OBIT	02025	1777,2011
	OBOY	02376	2263,2274
	OCCUR	02340	2335
	ODEN	01757	1776
	ODE	02026	2001,2024
	ODOR	02371	2302,2342
	OFT	02441	2336
	OGEE	02436	2267,2325,2331,2400,2425
	OINK	01775	1751
SET	OMAR	00062	1734,2003,2032,2033,2034,2035,2117,2201,2272,2403,2415
	OMEN	02021	2012,2014
	OMER	01761	1741,1743
	OMIT	02372	2275,2277
	OMNI	01737	1762
	ONION	02341	2337
	ONSET	02273	2373
	OOP	01770	1731,1767
	OOZE	02027	2000
	OPINE	02022	2021
	ORB	02377	2265,2340
	ORGY	02031	1736,1756,1766,2300,2301
	OUCH	01771	1732
	OUT	01765	1733,1740
	OVAL	02431	2264
	OVARY	02321	2314,2315
	OVER	02010	2022
	OZONE	01752	1774
	PHI	00246	51,537
	P	00245	14,155,453,466,473,576,613,712,735,1011
	PTB1	03021	3007
	PUTB	03007	1042,1365
	R0.5	03353	3172,3240
	RAD	03367	3261,3263,3310,3312
	RAD1	03160	3111
	RAD2	03161	3133
	RADDS	03464	3425,3427
	RAGS	03060	3070
	RAJ	02642	2502,2512
	RALF2	03155	3052

RPIG	03157	1536,3105,3167
RDUBL	03156	3103
RF0	03455	3420
REACH	02343	2313
RFCH	03425	3461
REVEN	03324	3230,3323
RFACM	03367	3202,3204,3211,3212,3213,3214,3216,3260,3271,3305
RFACT	02622	2456,2464,2465,2474
RFIX1	03372	1326,1476,3332
RFLAG	02367	2346
RFLO1	03354	3203,3215,3243,3245,3254,3275,3300,3327
RFLOM	03355	3201,3267
RG1	01420	1444
RG3	01463	1447
RG4	01513	1532
RGAD	00411	357,375
RGA	01670	1335,1440
RGDI	01672	1426,1431
RGERR	01671	0,1415,1441,1443,1445,1463
RGET1	01311	1325
RGFRK	00333	140
RGINI	01000	353
RGMAX	01677	1427
RGMX	01726	1677,1700
RGUP	01337	1307,1336
RGX.2	01470	1465
RGYPC	01673	1416,1433,1436,1457,1703,1706,1707,1714,1717,1720,1723
RIB	02620	2454,2461,2467,2510,2513
RICH	02551	2442,2443,2444
RICJ	02661	2520,2527
RIC	02621	2455,2460,2462
RIDEL	03363	3242,3244,3246,3250,3251,3252,3253,3255,3257,3272,3274,3276,3303,3306
RIGS	03070	3065
RIM	02576	2451,2466,2470
RIMU	02576	2447,2457,2472,2473,2536
RIN1	03111	3151
RIN2	03124	3112,3121,3130,3134,3143,3146,3150
RIN3	03130	3114
RIN4	03131	3115
RIN5	03144	3140
RIRS	03451	3414,3415,3416
RISK	03076	3155
RKU	03357	3231,3270,3273,3277,3301,3302
RKC	00605	162,657,670
RLOC1	02460	2452,2503
RLOC2	02501	2476,2500,2501
RLOC3	02505	2517,2521
RLOC4	02526	2533,2545
RMAGN	03352	3177,3200
RMAG	03154	3032,3033,3054
RMP1	02577	
RNPR1	03371	3223,3226,3331,3333
RN	03356	3222,3237,3326,3330
RNTR0	03226	3337,3343
RNTR1	03222	3344
RNTR2	03263	3313,3317

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       RNTR3    03250   3256
       RNTR4    03344   3341
       RNTR5    03211   3210,3217
       ROCK     03133   3131
       ROUD     03231
       ROGS     03061   3063,3067
       ROLL     03151   3132
       R.       02033   1753,2344,2350,2417
       RSAV2    03320   3232,3315
       RSAV3    03321   3233
       RSAVE    02600   2537,2541
       RSTOR    02332   2330,2364,2366
       RSTOT    02426   2414
       RSTRJ    02415   2402
       RSTR1    00001   541,546,730,1045,1120
       RSUM1    03433   3423,3450,3456
       RSUM2    03436   3424,3447,3457
       RSUM3    03437   3426,3443
       RSUM4    03440   3430
       RSUM5    03363   3247,3265,3266,3322
       RSUM6    03443   3434,3442,3444,3446
       RSUM7    03441   3431
       RSUMC    02661   2511,2514,2515
       RSUMD    02662   2525,2530,2531
       RSUM     03414   3056,3107,3221
       RTAB     02117   2033
       RTEMP    03370   3304,3307
       RUP0     03401   3407
       RUP1     03402   3404
       RUP2     03407   3377,3406
       RUP3     03410   3373,3374,3375
       RUPDA    03373   3071,3152,3345
       RX2.0    03072   3024,3025,3026,3076,3077,3100,3153
       RX.5     03346   3162,3163,3164
       RZERO    02471   2524
LCTR    RLCTR
QUAL    UNQS              .
LCTR   //
       SFT      01777   217
       SRCH     02263   660,1057
       STAR     01125   1072,1117,1123
       START    02747   254,2762,2765,2770
       T1       00240   36,147,575,605,617,651,715,720,740,743,1001,1035,1047,1063,1064,1177,1274,1301,1501,1506,
                        2004,2317,2355,2407,2421,2446,2751,3042
       T2       00241   40,622,652,1002,1040,1052,1061,1066,1200,1277,1302,1504,1507,2006,2410,2422,2754,3040
       TEMP     00202   102,104,105,111,510,511,517,531,534,536,620,624,1021,1022,1023,1030,1136,1137,1155,1213,1220,
                        1222,1227,1275,1300,1356,1502,1505,1544,1546,1554,1555,1621,1624,1625,1633,1636,1746,1752,
                        2307,2322,2324,2326,2332,2351,2360,2362,2700,2701,2702,2704,2705,2735,2742,2744,2745,2752,
                        2755,3036,3041,3043,3044,3046,3047
       TG02     00174   654,1004,1017,1037
       TG0      00173   0,653,740,744,1003,1020,1034,2446
       TL2      00177   2007,2412
       TL       00176   2005,2317,2411
       TMIN2    00171   430,471,476,501,623,1031,1051
       TMIN     00170   432,460,463,574,616,715,721,1024,1046
       TR2      00201   2424
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SYMBOL REFERENCE DATA

IRG2	00221	60,67,215,1537,2756,2757,2771,3050,3051,3106,3170
TRIGU	00214	63,422,424,431,3053
IR	00200	2355,2423
UPDAT	02663	1537,2760,3405
W	02034	1754,2305,2310,2323,2343,2347,2361,2404,2416
WTAB	02201	2034
X2.0	03024	767,1354
X.50	03162	754
Y0	00226	0,1142,1210,1235,1321,1344,1367,1407,1525,1556,2542,2777,3011
Y0(2)	00227	0,354,1205,1216,1217,1225,1226,1231,1323,1346,1370,1406,1410,1411,1530,1570,2540,3000,3013
YCLOW	00332	0,1422,1425
YDOT	00224	0,117,1151,1404,1520,2677,3403
YN2	00325	410,1324,1527
YN	00324	1522,1524
Y	00223	0,1141,1211,1236,1343,1420,1526,1560,1561,1632,1637,2543,2775,3012
Y(2)	00225	0,1234,1237,1345,1531,1557,1562,1635,1640,2544,2776,3014
(N)	00237	34,334,545,550,1140,1145,1310,1342,1366,1403,1417,1512,1551,1567,1616,2522,2665,2774,3010,3057,3110,3220,3401,3432

$DATA

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           IBLDR                                          02/17/69                          PAGE
      * MEMORY MAP *

SYSTEM                                   00000 THRU  02717
FILE BLOCK ORIGIN                        02720
FILES        1.      UNIT05
             2.      UNIT06
             3.      UNIT16
FILE LIST ORIGIN                         02764
PRE-EXECUTION INITIALIZATION             02772
CALL ON OBJECT PROGRAM                   03025
OBJECT PROGRAM                           03030 THRU  65771

     DECK   ORIGIN        CONTROL SECTIONS (/NAME/=NON 0 LENGTH, (LOC)=DELETED, 'LOC'=MOVED, *=NOT REFERENCED)

  1. MAIN     03030     /DATA  / 03031     /HBANK1/ 03105     /CRSR  / 03546     /NEW   / 03561     /EPSTN / 03563
                        /RSN   / 03565     /GAUSS / 03566     /POWLOS/ 03575     /RECT  / 03620     /ROOTS / 17405
                        /CONST / 17407     /GRAPH1/ 17416     /GRAPH0/ 17426      ......  21470 *
  2. INPU     21504     /DATA  /(03031)    /HBANK1/(03105)    /CRSR  /(03546)    /CONST /(17407)    /NEW   /(03561)
                        /RECT  /(03620)    /RSN   /(03565)    /RBLK1 / 21505     /GRAPH0/(17426)    /GRAPH1/(17416)
                        /GRAPH2/ 21512      INPUT    23676
  3. OUTPU    23712     /EPSTN /(03563)    /DATA  /(03031)    /HBANK1/(03105)    /CRSR  /(03546)    /GAUSS /(03566)
                        /POWLOS/(03575)    /GRAPH2/(21512)    /RECT  /(03620)    /ROOTS /(17405)     OUTPUT  26606
  4. SC       26625     /GRAPH0/(17426)    /GRAPH1/(17416)    /CONST /(17407)
  5. SCA      26625      PRAM     26652
  6. CALCO    26720     /GRAPH0/(17426)    /GRAPH1/(17416)     CALCO4  30656      CALCO5  30734      CALCO1  31012
                         CALCO2  31015      CALCO3  31020
  7. DENS     31023     /RECT  /(03620)    /GRAPH0/(17426)    /DATA  /(03031)    /HBANK1/(03105)    /RBLK1 /(21505)
                         DENSE   32206
  8. FIEL     32222     /EXFLD / 32223     /DATA  /(03031)    /HBANK1/(03105)    /GAUSS /(03566)    /CRSR  /(03546)
                         FIELD   32472
  9. POWER    32504     /DATA  /(03031)    /HBANK1/(03105)    /POWLOS/(03575)    /CRSR  /(03546)    /GAUSS /(03566)
                        /EXFLD /(32223)     POWERL  34735
 10. FORC     34747     /DATA  /(03031)    /HBANK1/(03105)     FORCE   34774
 11. COL      35006      COLL    35253
 12. CST      35304      CSINT   36271
 13. POLA     36330     /DATA  /(03031)    /HBANK1/(03105)    /CPSR  /(03546)     POLAR   36541
 14. IO       36553      TOR     36661
 15. MIN      36677      MINV    37434
 16. SMK2     37535      SMARK   37535      SMARK   (37535)    TRA14   37740      TRA24   37745      ON      37752
                         ON     (37752)     OFF     37773      OFF    (37773)
 17. MARS     40147      MARK    40147      HC      40334 *    NT      40335 *    TGLO    40342 *    Y       40372 *
                         YDOT    40373 *    Y121    40374 *    Y0      40375 *    Y0121   40376 *    EHBAR   40475
                         ELBAR   40470      HMAXI   40477      HMINT   40500      YCLOW   40501      RGERR   42040
 18. .LXCON   43634      .LXSTR  43634 *    .LXSIP  43637      .LXOUT  43705      .LXFRP  43714      .IXCAI  43717 *
                         .LXRIN  43717      IREXIT  43717 *    .DBCLS  44101 *    .LXARG  44251      .IO     44274 *
                         .CLSE   44302      .LFBL   44303 *    .LUNB   44304      .DFOUT  44305
 19. .IODEF   44311      .DEFIN  44311      .AITAC  44315 *    .CLOSF  44317      .OPEN   44321      .READ   44323
                         .WRITE  44325      .BSR    44335      .READR  44345 *    .PELES  44347 *    .IAREA  44360 *
                         .LFBLK  44376      .LISX   44401 *    .RLHLD  44411 *    .AREA1  44414      .LUNBL  44422 *
                         .ENTRY  44426      .GOA    44463      .GO     44467      .DERR   44503      .NOPXI  44504
                         .COMXI  44506      .FX34   44530
 20. .IOCSF   44535
 21. .LXSL    47037      .LXSEL  47037      .LXSL1  47040      .LXTST  47043 *    .IXOVL  47103 *    .IXMOD  47145 *
                         .LXIND  47171 *    .LXDIS  47174 *    .LXFLG  47175 *    .ITCH   47176
 22. .FPTRP   47204      .FFPT.  47204 *    .FPOUT  47341      .FPARG  47347      /.COUNT/ 47351 *   OVFLOW  47415 *
 23. .ERAS.   47424      E.1     47424      E.2     47425      E.3     47426      E.4     47427
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* MEMORY MAP *

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 24. .XCC.    47430   CC.1     47430    CC.2     47431    CC.3     47432    CC.4     47433
 25. XIT      47434   EXIT     47434    .EXIT.   47434
 26. FXEM     47435   FMTLOC   47435 *  EOFCL.   47436    .RULD.   47437    .FXEM.   47440    .FXOUT   47776
                      .FXARG   50004    /.OPTW./ 50060
 27. FOUT     50071   .FOUT.   50071
 28. FCNV     50465   .FCON.   50465    .FCNV.   50510    .ENDFS   50522    .CNVSW   50524    .FDX1    50530
                      .FDX2    50531    .DBC     50533    .DBC10   50671    .DBC20   50717    .DDSW    50735
                      .DUFIX   50741    .FIXSW   50742    .DDBC    51007    .DDRS1   51247    .DDRS2   51251
                      .D1      51254    .D2      51256    .FERR2   51343 *  .ANPT    51377    .ONPT    51414
                      .LNTP    51477    .AOUT    51546    .DFLT    51564    .FLT     51720    .DEXPN   52010
                      .FXD     52011    .HOUT    52146    .INTG    52216    .LOUT    52300    .OOUT    52317
                      .XCF     52350    .TEST    53073    .KOUNT   53076    .LIST    53101    .DONE    53112
                      .OUTBF   53156    .BUF     53205    .OSTO    53206    .WIDTH   53207    .GAIN    53210
                      .GAIN1   53211    .FBDBF   53221    .DUDFL   53245    .DDFLG   53246    .MOD     53247
                      .PEX     53250    .FEXP    53251    .DIG     53252
 29. FIOS     53267   .FIOS.   53267    .FSEL.   53437    .FILR.   53443    .FRTB.   53452 *  .FRTD.   53457
                      .FILL.   53462    .FCLS    53464 *  .FOPN    53470 *  REOF     53474 *  .TOUT.   53642
                      .REEU    53650 *  .BIN     53651 *  .FCT     53652 *  .FCKSZ   53654 *
 30. FIOH     53764   .FIOH.   53764    .FFIL.   54547    .FRTN.   54574
 31. FWRD     54772   .FWRD.   54772
 32. FRDD     55016   .FRDD.   55016
 33. FRDU     55044   .FRDU.   55044
 34. UN05     55105   .UN05.   55105
 35. UN06     55106   .UN06.   55106    .BUFSZ   55107
 36. FIOU     55112   .FIOU.   55112    .CTUIO   55610    .NMLST   55633    .NAME.   56737    .TNTAP   56740
 37. FLOG     57363   ALOG10   57363    ALOG     57364
 38. FXPF     57567   EXP      57567
 39. FSCN     57710   COS      57710    SIN      57711
 40. FSQR     60104   SQRT     60104
 41. FATN     60157   ATAN2    60157    ATAN     60160
 42. FXP1     60411   .XP1.    60411
 43. FXP2     60525   .XP2.    60525
 44. FXP3     60643   .XP3.    60643
 45. FSLDI    60770   .FSLI.   61006    .FSDI.   61014 *
 46. FSLI     61025   .SLI.    61025    .SLI1.   61032    .SDI.    61040    .SDI1.   61046
 47. FSLDO    61061   .FSLO.   61077    .FSDO.   61105 *
 48. FSLO     61116   .SLO.    61116    .SLO2.   61124    .SDO.    61131    .SDO2.   61140
 49. FCAB     61152   CABS     61152
 50. FCAS     61212   .CFMP.   61212    .CFDP.   61213
 51. FCSQ     61337   CSQRT    61337
 52. FTNC     61413   COTAN    61413 *  TAN      61414    CRIT     61557 *
 53. FASC     61636   ARCOS    61636    ARSIN    61637 *
 54. PLT770   61767   OFFSET   61770 *  WHERE    62006    FACTOR   62023 *  PLOTS    62030    PLOT     62113
 55. SYMBLZ   63304   SYMBOL   63304
 56. AXISZ    64110   AXIS     64674
 57. LINEZ    64746   LINE     65300
 58. NUMBRZ   65361   NUMBER   65732

I/O BUFFERS                         65772 THRU  77077

UNUSED CORE                         77100 THRU  77211
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        IBLDR                                                  02/06/69                     PAGE
      * MEMORY MAP *

SYSTEM                                 00000 THRU 02717
FILE BLOCK ORIGIN                      02720
FILES          1.     UNIT05
               2.     UNIT06
               3.     UNIT16
FILE LIST ORIGIN                       02764
PRE-EXECUTION INITIALIZATION           02772
CALL ON OBJECT PROGRAM                 03025
OBJECT PROGRAM                         03030 THRU 65754

     DECK   ORIGIN      CONTROL SECTIONS (/NAME/=NON 0 LENGTH, (LOC)=DELETED, 'LOC'=MOVED, *=NOT REFERENCED)

  1. MAIN     03030    /DATA  / 03031    /HBANK1/ 03105    /CRSR  / 03546    /NEW   / 03561    /EPSTN / 03563
                       /RSN   / 03565    /GAUSS / 03566    /POWLOS/ 03575    /RECT  / 03620    /ROOTS / 17405
                       /CONST / 17407    /GRAPH1/ 17416    /GRAPH0/ 17426    ...... 21470 *
  2. INPU     21504    /DATA  /(03031)   /HBANK1/(03105)   /CRSR  /(03546)   /CONST /(17407)   /NEW   /(03561)
                       /RECT  /(03620)   /RSN   /(03565)   /RBLK1 / 21505    /GRAPH0/(17426)   /GRAPH1/(17416)
                       /GRAPH2/ 21512     INPUT   23676
  3. OUTPU    23712    /EPSTN /(03563)   /DATA  /(03031)   /HBANK1/(03105)   /CRSR  /(03546)   /GAUSS /(03566)
                       /POWLOS/(03575)   /GRAPH2/(21512)   /RECT  /(03620)   /ROOTS /(17405)    OUTPUT  26606
  4. SC       26625    /GRAPH0/(17426)   /GRAPH1/(17416)   /CONST /(17407)
  5. SCA      26625     PRAM    26652
  6. CALCO    26720    /GRAPH0/(17426)   /GRAPH1/(17416)    CALC04  30656     CALC05  30734     CALC01  31012
                        CALC02  31015     CALC03  31020
  7. DENS     31023    /RECT  /(03620)   /DATA  /(03031)   /HBANK1/(03105)   /RBLK1 /(21505)    DENSE   32171
  8. FIEL     32205    /EXFLD / 32206    /DATA  /(03031)   /HBANK1/(03105)   /GAUSS /(03566)   /CRSR  /(03546)
                        FIELD   32455
  9. POWER    32467    /DATA  /(03031)   /HBANK1/(03105)   /POWLOS/(03575)   /CRSR  /(03546)   /GAUSS /(03566)
                       /EXFLD /(32206)    POWFRL  34720
 10. FORC     34732    /DATA  /(03031)   /HBANK1/(03105)    FORCE   34757
 11. COL      34771     COLL    35236
 12. CST      35267     CSINT   36254
 13. POLA     36313    /DATA  /(03031)   /HBANK1/(03105)   /CRSR  /(03546)    POLAR   36524
 14. TO       36536     TOR     36644
 15. MIN      36662     MINV    37417
 16. SMK2     37520     SMARK   37520     SMARK  (37520)    TRA14   37723     TRA24   37730     ON      37735
                        ON     (37735)    OFF     37756     OFF    (37756)
 17. MARS     40132     MARK    40132     HC      40317 *   NT      40320 *   TGLO    40325 *   Y       40355 *
                        YOUT    40356 *   Y121    40357 *   YO      40360 *   YO121   40361 *   EUBAR   40460
                        ELBAR   40461     HMAXI   40462     HMINT   40463     YCLOW   40464     RGEPR   42023
 18. .LXCON   43617    .LXSIR   43617 *  .LXSIP   43622    .LXOUT   43670    .LXERR   43677    .LXCAL   43702 *
                       .LXRTN   43702     IREXIT  43702 *  .DBCLS   44064 *  .LXARG   44234    .LO      44257 *
                       .CLSE    44265    .LFBL    44266 *  .LUNB    44267    .DFOUT   44270
 19. .IODEF   44274    .DEFIN   44274    .AITAC   44300 *  .CLOSE   44302    .OPEN    44304    .READ    44306
                       .WRITE   44310    .BSR     44320    .READR   44330 *  .RELES   44332 *  .LAREA   44343 *
                       .LFBLK   44361    .LISX    44364 *  .RLHLD   44374 *  .AREA1   44377    .LUNBL   44405 *
                       .ENTRY   44411    .GUA     44446    .GO      44452    .DERR    44466    .NOPXI   44467
                       .COMXI   44471    .FX34    44513
 20. .IOCSF   44520
 21. .LXSL    47022    .LXSEL   47022    .LXSL1   47023    .LXTST   47026 *  .LXOVI   47066 *  .LXMOD   47130 *
                       .LXIND   47154 *  .LXDIS   47157 *  .LXFLG   47160 *  .LTCH    47161
 22. .FPTRP   47167    .FPPI.   47167 *  .FPOUT   47324    .FPARG   47332    /.COUNT/ 47334 *   OVFLOW  47400 *
 23. .ERAS.   47407     E.1     47407     E.2     47410     E.3     47411     E.4     47412
 24. .XCC.    47413     CC.1    47413     CC.2    47414     CC.3    47415     CC.4    47416
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 * MEMORY MAP *

 25. XIT     47417     EXIT     47417    .EXIT.   47417
 26. FXEM    47420     FMILOC   47420 *  EOFCL.   47421   .RULD.   47422   .FXEM.   47423   .FXOUT  47761
                       .FXARG   47767    /.OPTW./ 50043
 27. FOUT    50054     .FOUT.   50054
 28. FCNV    50450     .FCON.   50450    .FCNV.   50473   .ENDFS   50505   .CNVSW   50507   .FDX1   50513
                       .FDX2    50514    .DBC     50516   .DBC10   50654   .DBC20   50702   .DDSW   50720
                       .DDFIX   50724    .FIXSW   50725   .DDBC    50772   .DDRS1   51232   .DDRS2  51234
                       .D1      51237    .D2      51241   .FERR2   51326 * .ANPT    51362   .ONPT   51377
                       .LNTP    51462    .AOUT    51531   .DFLT    51547   .FLT     51703   .DEXPN  51773
                       .FXD     51774    .HOUT    52131   .INTG    52201   .LOUT    52263   .OOUT   52302
                       .XCF     52333    .TEST    53056   .KOUNT   53061   .LIST    53064   .DONE   53075
                       .OUTBF   53141    .BUF     53170   .OSTO    53171   .WIDTH   53172   .GAIN   53173
                       .GAIN1   53174    .FBDBF   53204   .DUDFL   53230   .DDFLG   53231   .MOD    53232
                       .PEX     53233    .FEXP    53234   .DIG     53235
 29. FIOS    53252     .FIOS.   53252    .FSEL.   53422   .FILR.   53426   .FRTB.   53435 * .FRTD.  53442
                       .FILL.   53445    .FCLS    53447 * .FOPN    53453 * REOF     53457 * .TOUT.  53625
                       .REED    53633 *  .BIN     53634 * .FCT     53635 * .FCKSZ   53637 *
 30. FIOH    53747     .FIOH.   53747    .FFIL.   54532   .FRTN.   54557
 31. FWRD    54755     .FWRD.   54755
 32. FRDD    55001     .FRDD.   55001
 33. FRDU    55027     .FRDU.   55027
 34. UN05    55070     .UN05.   55070
 35. UN06    55071     .UN06.   55071    .BUFSZ   55072
 36. FIOU    55075     .FIOU.   55075    .CTIIO   55573   .NMLST   55616   .NAME.   56722   .INTAP  56723
 37. FLOG    57346     ALOG10   57346    ALOG     57347
 38. FXPF    57552     EXP      57552
 39. FSCN    57673     COS      57673    SIN      57674
 40. FSQR    60067     SQRT     60067
 41. FAIN    60142     ATAN2    60142    ATAN     60143
 42. FXP1    60374     .XP1.    60374
 43. FXP2    60510     .XP2.    60510
 44. FXP3    60626     .XP3.    60626
 45. FSLDI   60753     .FSLI.   60771    .FSDI.   60777 *
 46. FSLI    61010     .SLI.    61010    .SLI1.   61015   .SDI.    61023   .SDI1.   61031
 47. FSLDO   61044     .FSLO.   61062    .FSDO.   61070 *
 48. FSLO    61101     .SLO.    61101    .SLO2.   61107   .SDO.    61114   .SDO2.   61123
 49. FCAB    61135     CABS     61135
 50. FCAS    61175     .CFMP.   61175    .CFDP.   61176
 51. FCSQ    61322     CSQRT    61322
 52. FTNC    61376     COTAN    61376 *  TAN      61377   CRIT     61542 *
 53. FASC    61621     ARCOS    61621    ARSIN    61622 *
 54. PLT770  61752     OFFSET   61753 *  WHERE    61771   FACTOR   62006 * PLOTS    62013   PLOT    62076
 55. SYMBLZ  63267     SYMBOL   63267
 56. AXISZ   64073     AXIS     64657
 57. LINEZ   64731     LINE     65263
 58. NUMBRZ  65344     NUMBER   65715

 I/O BUFFERS                 65755 THRU  77062

 UNUSED CORE                 77063 THRU  77211
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                    SAMPLE CASE GENERATED FOR DOCUMENTATION

        INITIAL RAY POSITION                      INITIAL RAY DIRECTION

        RO          9295.40                       AO        65.99
        THETAO        77.44                       BO         0.00
        PHIO          90.00                       DELAO      0.00

        RAY CHARACTERISTICS                       FIELD LINE

        FREQ     1.00                             LAMBDA    53.94
        MODE    -1                                L-VALUE    1.53

                  STOP CONDITIONS                 INTERVALS
                     MAX       MIN
        RADIUS    11000.0    6378.0               PRINT    200.0
        THETA       180.0       0.0               PLOT     100.0
        PHI         360.0       0.0               STEP      20.0

        PROGRAM OPTIONS                           OTHER INITIAL VALUES

        NPOWER  0                                 SCALE SIZE     0.707
        NPLOT   1                                 PKFRAC         0.050
        NOVER   0                                 HPRIME         1.176
        NAUTO   0                                 PKDFLN        60.549
        JTEST   2

UNDRFLOW AT 20504 IN MQ

UNDRFLOW AT 20520 IN AC AND MQ.

UNDRFLOW AT 20504 IN MQ

UNDRFLOW AT 20520 IN AC AND MQ.

UNDRFLOW AT 20504 IN MQ
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SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CD
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
2.0000000E 01	9.3041084E 03	7.7566658E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4031575E 01	3.7083140E-01	8.4940216E-01	-0.0000000E-39	8.5899997E-01	8.5899995E-01	3.2884926E-13
2.1583306E 01	1.0000023E 00	-9.0000000E 01	2.1791243E-05	1.2074153E 03	8.6929314E-06	8.0105249E-02
2.0000000E 02	9.3790591E 03	7.8663387E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919784E 02	3.5227335E-01	8.6049035E-01	0.0000000E-39	8.6454017E-01	8.6454015E-01	1.8393076E-13
2.1547645E 02	1.0000086E 00	-9.0000000E 01	1.2532970E-05	1.1775214E 03	5.1706413E-06	7.9732613E-01
4.0000000E 02	9.4549106E 03	7.9885571E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618443E 02	3.1247831E-01	8.7869874E-01	0.0000000E-39	8.6975418E-01	8.6975416E-01	1.0242290E-13
4.3024053E 02	1.0000001E 00	-9.0000000E 01	7.7818205E-06	1.1486853E 03	3.0565067E-06	1.5872814E 00
6.0000000E 02	9.5233201E 03	8.1110764E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136256E 02	2.7305632E-01	8.9420238E-01	0.0000000E-39	8.7415765E-01	8.7415764E-01	6.0527487E-14
6.4441360E 02	1.0000071E 00	-9.0000000E 01	1.6612134E-05	1.1237326E 03	1.9024320E-06	2.3712085E 00
8.0000000E 02	9.5831912E 03	8.2340916E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506111E 02	2.4719298E-01	9.0372165E-01	0.0000000E-39	8.7781720E-01	8.7781718E-01	3.8245256E-14
8.5809700E 02	1.0000027E 00	-9.0000000E 01	2.1914030E-05	1.1025245E 03	1.2563415E-06	3.1502037E 00
1.0000000E 03	9.6338651E 03	8.3576100E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775500E 03	2.1059714E-01	9.1457866E-01	0.0000000E-39	8.8080530E-01	8.8080528E-01	2.5948592E-14
1.0713754E 03	1.0000034E 00	-9.0000000E 01	9.8592200E-06	1.0848494E 03	8.8431544E-07	3.9251668E 00
1.2000000E 03	9.6763511E 03	8.4814052E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090642E 03	1.6285635E-01	9.2559346E-01	0.0000000E-39	8.8324545E-01	8.8324544E-01	1.8751383E-14
1.2843241E 03	1.0000041E 00	-9.0000000E 01	1.0791444E-05	1.0700884E 03	6.5878622E-07	4.6968806E 00
1.4000000E 03	9.7104039E 03	8.6054828E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398141E 03	1.2611563E-01	9.3235042E-01	0.0000000E-39	8.8518248E-01	8.8518245E-01	1.4453184E-14
1.4970117E 03	1.0000010E 00	-9.0000000E 01	2.3180092E-05	1.0580794E 03	5.2030317E-07	5.4660469E 00
1.6000000E 03	9.7346377E 03	8.7298759E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699834E 03	9.5122531E-02	9.3677850E-01	0.0000000E-39	8.8660226E-01	8.8660225E-01	1.2002435E-14
1.7094989E 03	1.0000070E 00	-9.0000000E 01	1.5447359E-05	1.0490262E 03	4.3987898E-07	6.2332779E 00
1.8000000E 03	9.7496772E 03	8.8544160E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997386E 03	4.7070662E-02	9.4092793E-01	0.0000000E-39	8.8756100E-01	8.8756102E-01	1.0686431E-14
1.9218413E 03	1.0000001E 00	-9.0000000E 01	9.0264119E-06	1.0426152E 03	3.9635041E-07	6.9991287E 00
2.0000000E 03	9.7562792E 03	8.9790206E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292425E 03	5.3855051E-04	9.4239670E-01	0.0000000E-39	8.8811183E-01	8.8811182E-01	1.0141845E-14
2.1340939E 03	1.0000062E 00	-9.0000000E 01	1.7753554E-05	1.0385536E 03	3.7861936E-07	7.7641417E 00
2.0026441E 03	9.7562800E 03	8.9806684E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3322757E 03	-9.9151940E-05	9.4239864E-01	0.0000000E-39	8.8811521E-01	8.8811520E-01	1.0141433E-14
2.1368996E 03	1.0000064E 00	-9.0000000E 01	1.7272333E-05	1.0385236E 03	3.7861733E-07	7.7742522E 00

RDOT = -0.256018E-10

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION - MOD AND ARG	COLATITUDE Y2	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
2.2000000E 03	9.7533718E 03	9.1036575E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.5587009E 03	-3.0006336E-02	9.4176053E-01	0.0000000E-39	8.8781328E-01	8.8781327E-01	1.0383982E-14
2.3463297E 03	1.0000025E 00	-9.0000000E 01	2.1992870E-05	1.0408437E 03	3.8631913E-07	8.5290028E 00
2.4000000E 03	9.7405720E 03	9.2282115E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.7883552E 03	-7.0891676E-02	9.3911811E-01	0.0000000E-39	8.8696846E-01	8.8696845E-01	1.1466033E-14
2.5586364E 03	1.0000024E 00	-9.0000000E 01	1.0138950E-05	1.0466211E 03	4.2215269E-07	9.2945173E 00
2.6000000E 03	9.7192051E 03	9.3526370E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.0183646E 03	-1.2064937E-01	9.3334941E-01	0.0000000E-39	8.8569740E-01	8.8569738E-01	1.3509765E-14
2.7710679E 03	1.0000049E 00	-9.0000000E 01	1.1550780E-05	1.0548366E 03	4.8951262E-07	1.0061215E 01
2.8000000E 03	9.6891510E 03	9.4768933E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.2488991E 03	-1.5656663E-01	9.2706798E-01	0.0000000E-39	8.8396815E-01	8.8396814E-01	1.7003786E-14
2.9836814E 03	1.0000005E 00	-9.0000000E 01	2.3382330E-05	1.0656361E 03	6.0283022E-07	1.0829664E 01
3.0000000E 03	9.6493534E 03	9.6007865E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.4801365E 03	-1.8710618E-01	9.2015684E-01	0.0000000E-39	8.8169734E-01	8.8169732E-01	2.3049394E-14
3.1965358E 03	1.0000068E 00	-9.0000000E 01	1.4377438E-05	1.0794885E 03	7.9426515E-07	1.1600455E 01
3.2000000E 03	9.6008059E 03	9.7243106E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.7122717E 03	-2.3219256E-01	9.0827195E-01	0.0000000E-39	8.7887131E-01	8.7887131E-01	3.3414795E-14
3.4096949E 03	1.0000003E 00	-9.0000000E 01	8.4454776E-06	1.0963403E 03	1.1119204E-06	1.2374239E 01
3.4000000E 03	9.5443655E 03	9.8475507E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.9455325E 03	-2.7538235E-01	8.9483298E-01	0.0000000E-39	8.7546400E-01	8.7546396E-01	5.1496354E-14
3.6232323E 03	1.0000072E 00	-9.0000000E 01	1.6913921E-05	1.1162171E 03	1.6441106E-06	1.3151775E 01
3.6000000E 03	9.4792747E 03	9.9703398E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.1801808E 03	-2.9854333E-01	8.8443135E-01	0.0000000E-39	8.7134694E-01	8.7134693E-01	8.4905355E-14
3.8372307E 03	1.0000025E 00	-9.0000000E 01	2.1458650E-05	1.1397123E 03	2.5813040E-06	1.3933936E 01
3.8000000E 03	9.4054098E 03	1.0092554E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.4165199E 03	-3.3120860E-01	8.6988204E-01	0.0000000E-39	8.6639392E-01	8.6639389E-01	1.5002362E-13
4.0517841E 03	1.0000035E 00	-9.0000000E 01	9.2783632E-06	1.1673512E 03	4.3070709E-06	1.4721733E 01
4.0000000E 03	9.3240365E 03	1.0214426E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.6549209E 03	-3.7075416E-01	8.5032947E-01	0.0000000E-39	8.6051887E-01	8.6051886E-01	2.8165519E-13
4.2670051E 03	1.0000038E 00	-9.0000000E 01	8.7714449E-06	1.1993057E 03	7.5706798E-06	1.5516403E 01
4.2000000E 03	9.2353370E 03	1.0336028E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.8958493E 03	-4.0079329E-01	8.3240772E-01	0.0000000E-39	8.5353786E-01	8.5353786E-01	5.6172143E-13
4.4830317E 03	1.0000049E 00	-9.0000000E 01	1.9825234E-05	1.2362420E 03	1.4000840E-05	1.6319498E 01
4.4000000E 03	9.1386191E 03	1.0457172E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.1398913E 03	-4.1943090E-01	8.1805645E-01	0.0000000E-39	8.4513867E-01	8.4513863E-01	1.1982238E-12
4.7000334E 03	1.0000060E 00	-9.0000000E 01	1.8242112E-05	1.2794121E 03	2.7374596E-05	1.7132971E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
4.6000000E 03	9.0341672E 03	1.0577948E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.3878067E 03	-4.4653989E-01	7.9722627E-01	0.0000000E-39	8.3496762E-01	8.3496760E-01	2.7334357E-12
4.9182239E 03	1.0000029E 00	-9.0000000E 01	7.8593554E-06	1.3300455E 03	5.6476075E-05	1.7959356E 01
4.8000000E 03	8.9227870E 03	1.0698736E 02	8.9999987E 01	9.9999998E-01	-0.0000000E-39	0.0000000E-39
5.6406244E 03	-4.7624905E-01	7.7186092E-01	0.0000000E-39	8.2258245E-01	8.2258243E-01	6.6443715E-12
5.1378847E 03	1.0000040E 00	-9.0000000E 01	7.7193462E-06	1.3895433E 03	1.2225591E-04	1.8802081E 01
5.0000000E 03	8.8044321E 03	1.0819754E 02	8.9999987E 01	9.9999996E-01	-0.0000000E-39	0.0000000E-39
5.8997850E 03	-4.9878174E-01	7.4731603E-01	0.0000000E-39	8.0726448E-01	8.0726446E-01	1.7274905E-11
5.3593978E 03	1.0000106E 00	-9.0000000E 01	1.6302467E-05	1.4603148E 03	2.7778626E-04	1.9665950E 01
5.2000000E 03	8.6784774E 03	1.0941081E 02	8.9999987E 01	9.9999990E-01	-0.0000000E-39	0.0000000E-39
6.1673809E 03	-5.0963041E-01	7.2673517E-01	0.0000000E-39	7.8786719E-01	7.8786717E-01	4.8510695E-11
5.5832983E 03	1.0000013E 00	-9.0000000E 01	2.2563366E-05	1.5461703E 03	6.6541135E-04	2.0557936E 01
5.4000000E 03	8.5444343E 03	1.1063023E 02	8.9999987E 01	9.9999971E-01	-0.0000000E-39	0.0000000E-39
6.4466136E 03	-5.2055878E-01	7.0118118E-01	0.0000000E-39	7.6263650E-01	7.6263649E-01	1.4875621E-10
5.8103724E 03	1.0000116E 00	-9.0000000E 01	1.1983707E-05	1.6526221E 03	1.6861419E-03	2.1488712E 01
5.6000000E 03	8.4020784E 03	1.1186423E 02	8.9999987E 01	9.9999910E-01	-0.0000000E-39	0.0000000E-39
6.7427452E 03	-5.3294584E-01	6.6688009E-01	0.0000000E-39	7.2876033E-01	7.2876032E-01	5.0449349E-10
6.0418512E 03	1.0000011E 00	-9.0000000E 01	9.6960802E-06	1.7877511E 03	4.5268798E-03	2.2475817E 01
5.8000000E 03	8.2502322E 03	1.1312484E 02	8.9999987E 01	9.9999690E-01	-0.0000000E-39	0.0000000E-39
7.0652869E 03	-5.3844530E-01	6.2550457E-01	0.0000000E-39	6.8117932E-01	6.8117930E-01	1.9454402E-09
6.2798304E 03	1.0000045E 00	-9.0000000E 01	1.2596680E-05	1.9652429E 03	1.2982543E-02	2.3550956E 01
6.0000000E 03	8.0859960E 03	1.1443288E 02	8.9999987E 01	9.9998741E-01	-0.0000000E-39	0.0000000E-39
7.4340717E 03	-5.2961257E-01	5.7372595E-01	0.0000000E-39	6.0965095E-01	6.0965094E-01	9.0554304E-09
6.5283505E 03	1.0000205E 00	-9.0000000E 01	2.0025418E-05	2.2105284E 03	4.0581925E-02	2.4780239E 01
6.2000000E 03	7.9021177E 03	1.1583795E 02	8.9999987E 01	9.9993350E-01	-0.0000000E-39	0.0000000E-39
7.9026678E 03	-4.9064412E-01	4.9799377E-01	0.0000000E-39	4.8872946E-01	4.8872944E-01	5.9473729E-08
6.7971518E 03	1.0000276E 00	-9.0000000E 01	4.0952171E-05	2.5808514E 03	1.4541343E-01	2.6342226E 01
6.4000000E 03	7.6652626E 03	1.1756780E 02	8.9999987E 01	9.9923291E-01	-0.0000000E-39	0.0000000E-39
8.7837766E 03	-3.2804337E-01	3.0693748E-01	0.0000000E-39	2.0182307E-01	2.0182307E-01	1.4124313E-06
7.1308394E 03	1.0000614E 00	-9.0000000E 01	2.7707806E-04	3.3209406E 03	7.5289610E-01	2.9279262E 01
6.4399581E 03	7.5721345E 03	1.1823083E 02	8.9999987E 01	9.9613941E-01	-0.0000000E-39	0.0000000E-39
9.8500502E 03	-3.3383497E-05	-9.5281497E-04	0.0000000E-39	9.0897083E-07	9.0897082E-07	1.1258891E 00
7.2590909E 03	1.4988323E 00	9.0000006E 01	5.9509908E 04	3.7784665E 03	1.4373578E 00	3.2833500E 01

RDOT = 0.300702E 03

6.6000000E 03	7.8186420E 03	1.1645662E 02	8.9999987E 01	9.9241554E-01	-0.0000000E-39	0.0000000E-39
1.1552453E 04	4.5268922E-01	-4.5387141E-01	0.0000000E-39	4.1092679E-01	4.1092678E-01	1.5466445E-07
7.6019791E 03	1.0000004E 00	9.0000000E 01	6.1725917E-05	2.7970001E 03	2.5957751E-01	3.8508176E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
6.8000000E 03	9.0156168E 03	1.1497856E 02	8.9999987E 01	9.9229129E-01	-0.0000000E-39	0.0000000E-39
1.2103340E 04	5.1523870E-01	-5.5164032E-01	0.0000000E-39	5.6977799E-01	5.6977797E-01	1.8135833E-08
7.8857478E 03	1.0000005E 00	9.0000000E 01	2.7363268E-05	2.3380222E 03	6.6140081E-02	4.0344465E 01
7.0000000E 03	8.1865203E 03	1.1364169E 02	8.9999987E 01	9.9227326E-01	-0.0000000E-39	0.0000000E-39
1.2501771E 04	5.3484138E-01	-6.0855538E-01	0.0000000E-39	6.5640713E-01	6.5640711E-01	3.4927727E-09
8.1405925E 03	1.0000011E 00	9.0000000E 01	1.8864516E-05	2.0527903E 03	2.0200305E-02	4.1672571E 01
7.2000000E 03	8.3428774E 03	1.1230562E 02	8.9999987E 01	9.9226943E-01	-0.0000000E-39	0.0000000E-39
1.2839439E 04	5.3739858E-01	-6.5042619E-01	0.0000000E-39	7.1185149E-01	7.1185146E-01	8.4830332E-10
8.3821237E 03	1.0000011E 00	9.0000000E 01	1.4668803E-05	1.8522921E 03	6.8261424E-03	4.2798130E 01
7.4000000E 03	8.4686642E 03	1.1112181E 02	8.9999987E 01	9.9226844E-01	-0.0000000E-39	0.0000000E-39
1.3144621E 04	5.3027412E-01	-6.8496159E-01	0.0000000E-39	7.5036305E-01	7.5036303E-01	2.3900814E-10
8.6158774E 03	1.0000002E 00	9.0000000E 01	1.2373409E-05	1.7025110E 03	2.4826449E-03	4.3815402E 01
7.6000000E 03	8.6256927E 03	1.0989641E 02	8.9999987E 01	9.9226815E-01	-0.0000000E-39	0.0000000E-39
1.3429806E 04	5.1701558E-01	-7.1505410E-01	0.0000000E-39	7.7857887E-01	7.7857886E-01	7.5191972E-11
8.8445264E 03	1.0000000E 00	9.0000000E 01	1.1996634E-05	1.5860124E 03	9.5962344E-04	4.4766021E 01
7.8000000E 03	8.7548459E 03	1.0866143E 02	8.9999987E 01	9.9226805E-01	-0.0000000E-39	0.0000000E-39
1.3701579E 04	5.0027035E-01	-7.4147620E-01	0.0000000E-39	8.0005740E-01	8.0005737E-01	2.5883834E-11
9.0695828E 03	1.0000002E 00	9.0000000E 01	1.3450111E-05	1.4926772E 03	3.9179893E-04	4.5671929E 01
8.0000000E 03	8.8764929E 03	1.0747157E 02	8.9999987E 01	9.9226802E-01	-0.0000000E-39	0.0000000E-39
1.3963811E 04	4.8168565E-01	-7.6475066E-01	0.0000000E-39	8.1687841E-01	8.1687840E-01	9.6408418E-12
9.2919745E 03	1.0000000E 00	9.0000000E 01	1.4730776E-05	1.4162188E 03	1.6853182E-04	4.6546037E 01
8.2000000E 03	8.9907505E 03	1.0626334E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4216965E 04	4.6044391E-01	-7.8634090E-01	0.0000000E-39	8.3034061E-01	8.3034059E-01	3.8600900E-12
9.5123236E 03	1.0000005E 00	9.0000000E 01	1.3540360E-05	1.3525142E 03	7.6312902E-05	4.7396548E 01
8.4000000E 03	9.0977012E 03	1.0505471E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4468698E 04	4.3511170E-01	-8.0745301E-01	0.0000000E-39	8.4130257E-01	8.4130255E-01	1.6537542E-12
9.7310636E 03	1.0000001E 00	9.0000000E 01	1.2090531E-05	1.2987091E 03	3.6354116E-05	4.8228992E 01
8.6000000E 03	9.1973750E 03	1.0384443E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4714182E 04	4.0694400E-01	-8.2749397E-01	0.0000000E-39	8.5034970E-01	8.5034967E-01	7.5573527E-13
9.9485109E 03	1.0000001E 00	9.0000000E 01	1.3019496E-05	1.2527913E 03	1.8215836E-05	4.9047273E 01
8.8000000E 03	9.2896003E 03	1.0263119E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.4956275E 04	3.7851059E-01	-8.4534718E-01	0.0000000E-39	8.5788213E-01	8.5788211E-01	3.6805543E-13
1.0164904E 04	1.0000000E 00	9.0000000E 01	1.5211265E-05	1.2133721E 03	9.6116026E-06	4.9854250E 01
9.0000000E 03	9.3740654E 03	1.0141391E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5195626E 04	3.4918459E-01	-8.6154041E-01	0.0000000E-39	8.6418176E-01	8.6418173E-01	1.9115900E-13
1.0380430E 04	1.0000003E 00	9.0000000E 01	1.4742595E-05	1.1794698E 03	5.3521560E-06	5.0652088E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
9.2000000E 03	9.4506141E 03	1.0019236E 02	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5432741E 04	3.1603229E-01	-8.7726200E-01	0.0000000E-39	8.6946503E-01	8.6946501E-01	1.0586332E-13
1.0595236E 04	1.0000000E 00	9.0000000E 01	1.3205466E-05	1.1502943E 03	3.1485539E-06	5.1442470E 01
9.4000000E 03	9.5191812E 03	9.8966667E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5668024E 04	2.8045148E-01	-8.9176531E-01	0.0000000E-39	8.7389839E-01	8.7389839E-01	6.2476631E-14
1.0809443E 04	1.0000001E 00	9.0000000E 01	1.4332095E-05	1.1252157E 03	1.9576336E-06	5.2226745E 01
9.6000000E 03	9.5794746E 03	9.7736665E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.5901805E 04	2.4564439E-01	-9.0402183E-01	0.0000000E-39	8.7759665E-01	8.7759663E-01	3.9345983E-14
1.1023154E 04	9.9999999E-01	9.0000000E 01	1.6199269E-05	1.1038191E 03	1.2890357E-06	5.3006017E 01
9.8000000E 03	9.6311339E 03	9.6502371E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6134363E 04	2.0972222E-01	-9.1469123E-01	0.0000000E-39	8.8064346E-01	8.8064346E-01	2.6495707E-14
1.1236456E 04	1.0000002E 00	9.0000000E 01	1.4973576E-05	1.0858098E 03	9.0114630E-07	5.3781209E 01
1.0000000E 04	9.6740923E 03	9.5264431E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6365933E 04	1.7014555E-01	-9.2421018E-01	0.0000000E-39	8.8311398E-01	8.8311397E-01	1.9077606E-14
1.1449423E 04	9.9999999E-01	9.0000000E 01	1.4074001E-05	1.0708869E 03	6.6914065E-07	5.4553111E 01
1.0200000E 04	9.7082855E 03	9.4023462E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6596725E 04	1.3017139E-01	-9.3172966E-01	0.0000000E-39	8.8506474E-01	8.8506474E-01	1.4688242E-14
1.1662125E 04	1.0000001E 00	9.0000000E 01	1.5889954E-05	1.0588213E 03	5.2798227E-07	5.5322417E 01
1.0400000E 04	9.7334000E 03	9.2779930E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.6826925E 04	9.1694817E-02	-9.3707988E-01	0.0000000E-39	8.8652664E-01	8.8652664E-01	1.2117002E-14
1.1874623E 04	1.0000001E 00	9.0000000E 01	1.6450377E-05	1.0495130E 03	4.4365498E-07	5.6089748E 01
1.0600000E 04	9.7492821E 03	9.1534641E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7056702E 04	5.1120044E-02	-9.4069759E-01	0.0000000E-39	8.8752522E-01	8.8752520E-01	1.0720111E-14
1.2086973E 04	1.0000001E 00	9.0000000E 01	1.4713411E-05	1.0428664E 03	3.9742639E-07	5.6855673E 01
1.0800000E 04	9.7560507E 03	9.0288507E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7286218E 04	8.6260205E-03	-9.4234359E-01	0.0000000E-39	8.8808585E-01	8.8808583E-01	1.0160932E-14
1.2299230E 04	1.0000001E 00	9.0000000E 01	1.5072413E-05	1.0387583E 03	3.7922009E-07	5.7620725E 01
1.0846431E 04	9.7562743E 03	8.9999169E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7339479E 04	4.2585988E-07	-9.4241841E-01	0.0000000E-39	8.8815248E-01	8.8815246E-01	1.0138060E-14
1.2348498E 04	9.9999999E-01	9.0000000E 01	1.4537934E-05	1.0381770E 03	3.7863385E-07	5.7798265E 01

RDOT = -0.107819E-09

1.1000000E 04	9.7536423E 03	8.9042212E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7515668E 04	-3.1898650E-02	-9.4171371E-01	0.0000000E-39	8.8784222E-01	8.8784222E-01	1.0361183E-14
1.2511463E 04	1.0000000E 00	9.0000000E 01	1.6747773E-05	1.0406271E 03	3.8560248E-07	5.8385561E 01
1.1200000E 04	9.7418979E 03	8.7796435E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7745306E 04	-7.1292518E-02	-9.3912849E-01	0.0000000E-39	8.8704495E-01	8.8704494E-01	1.1350454E-14
1.2723764E 04	1.0000001E 00	9.0000000E 01	1.5730328E-05	1.0461123E 03	4.1829643E-07	5.9151019E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH / GROUP PATH / RAY PATH	RADIUS / Y1 / POLARIZATION - MOD AND ARG	COLATITUDE / Y2	LONGITUDE / Y3 / DEL MU	ABSORPTION / MU**2 / N	DOPPLER SP. / Y**2 / NU	POWER LOSS / EPSTEIN CD / GROUP DELAY
1.1400000E 04	9.7209622E 03	8.6552052E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.7975289E 04	-1.1268877E-01	-9.3439713E-01	0.0000000E-39	8.8579676E-01	8.8579675E-01	1.3329988E-14
1.2936186E 04	9.9999999E-01	9.0000000E 01	1.4286140E-05	1.0542007E 03	4.8360261E-07	5.9917629E 01
1.1600000E 04	9.6910646E 03	8.5309726E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8205784E 04	-1.5530173E-01	-9.2767429E-01	0.0000000E-39	8.8408103E-01	8.8408101E-01	1.6756885E-14
1.3148786E 04	1.0000002E 00	9.0000000E 01	1.5562217E-05	1.0649434E 03	5.9492356E-07	6.0685947E 01
1.1800000E 04	9.6521852E 03	8.4070248E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8436970E 04	-1.9067842E-01	-9.1951088E-01	0.0000000E-39	8.8185852E-01	8.8185851E-01	2.2557459E-14
1.3361623E 04	1.0000000E 00	9.0000000E 01	1.6231197E-05	1.0785101E 03	7.7887334E-07	6.1456567E 01
1.2000000E 04	9.6044097E 03	8.2834369E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8669043E 04	-2.2796770E-01	-9.0945650E-01	0.0000000E-39	8.7908041E-01	8.7908038E-01	3.2509142E-14
1.3574761E 04	1.0000001E 00	9.0000000E 01	1.4323911E-05	1.0950981E 03	1.0845563E-06	6.2230144E 01
1.2200000E 04	9.5480913E 03	8.1602352E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.8902226E 04	-2.6574545E-01	-8.9725860E-01	0.0000000E-39	8.7569367E-01	8.7569363E-01	5.0049374E-14
1.3788272E 04	1.0000001E 00	9.0000000E 01	1.3952774E-05	1.1148888E 03	1.6023384E-06	6.3007420E 01
1.2400000E 04	9.4834436E 03	8.0374426E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9136776E 04	-3.0061479E-01	-8.8386356E-01	0.0000000E-39	8.7161943E-01	8.7161939E-01	8.2231394E-14
1.4002238E 04	1.0000001E 00	9.0000000E 01	1.5438533E-05	1.1381775E 03	2.5080389E-06	6.3789254E 01
1.2600000E 04	9.4105314E 03	7.9151016E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9372998E 04	-3.3262481E-01	-8.6954340E-01	0.0000000E-39	8.6674502E-01	8.6674499E-01	1.4422660E-13
1.4216753E 04	1.0000000E 00	9.0000000E 01	1.4930436E-05	1.1654038E 03	4.1572354E-06	6.4576659E 01
1.2800000E 04	9.3296013E 03	7.7932055E 01	8.9999987E 01	9.9226800E-01	-0.0000000E-39	0.0000000E-39
1.9611258E 04	-3.6454452E-01	-8.5325250E-01	0.0000000E-39	8.6093255E-01	8.6093253E-01	2.6979289E-13
1.4431929E 04	1.0000000E 00	9.0000000E 01	1.3085780E-05	1.1970722E 03	7.2849621E-06	6.5370858E 01
1.3000000E 04	9.2409858E 03	7.6710922E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
1.9852010E 04	-3.9545574E-01	-8.3523580E-01	0.0000000E-39	8.5400409E-01	8.5400407E-01	5.3755009E-13
1.4647900E 04	1.0000002E 00	9.0000000E 01	1.3208324E-05	1.2338120E 03	1.3464953E-05	6.6173367E 01
1.3200000E 04	9.1448372E 03	7.5505080E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
2.0095832E 04	-4.2300777E-01	-8.1656098E-01	0.0000000E-39	8.4570742E-01	8.4570740E-01	1.1412095E-12
1.4864833E 04	1.0000001E 00	9.0000000E 01	1.4492756E-05	1.2765319E 03	2.6223182E-05	6.6986106E 01
1.3400000E 04	9.0412130E 03	7.4295930E 01	8.9999987E 01	9.9226799E-01	-0.0000000E-39	0.0000000E-39
2.0343475E 04	-4.4767079E-01	-7.9704476E-01	0.0000000E-39	8.3568950E-01	8.3568949E-01	2.5853932E-12
1.5082941E 04	1.0000000E 00	9.0000000E 01	1.4017018E-05	1.3264913E 03	5.3790262E-05	6.7811584E 01
1.3600000E 04	8.9302416E 03	7.3088099E 01	8.9999987E 01	9.9226798E-01	-0.0000000E-39	0.0000000E-39
2.0595948E 04	-4.7114927E-01	-7.7555203E-01	0.0000000E-39	8.2346261E-01	8.2346258E-01	6.2601688E-12
1.5302499E 04	1.0000000E 00	9.0000000E 01	1.2434426E-05	1.3853692E 03	1.1611286E-04	6.8653159E 01

SAMPLE CASE GENERATED FOR DOCUMENTATION

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
1.3800000E 04	8.8120227E 03	7.1879375E 01	8.9999987E 01	9.9226796E-01	-0.0000000E-39	0.0000000E-39
2.0854655E 04	-4.9289190E-01	-7.5191908E-01	0.0000000E-39	8.0832474E-01	8.0832472E-01	1.6244030E-11
1.5523881E 04	1.0000001E 00	9.0000000E 01	1.2113422E-05	1.4555074E 03	2.6358472E-04	6.9515514E 01
1.4000000E 04	8.6864583E 03	7.0666925E 01	8.9999987E 01	9.9226790E-01	-0.0000000E-39	0.0000000E-39
2.1121633E 04	-5.1118992E-01	-7.2656618E-01	0.0000000E-39	7.8921355E-01	7.8921354E-01	4.5419231E-11
1.5747610E 04	1.0000003E 00	9.0000000E 01	1.3231398E-05	1.5403513E 03	6.2969025E-04	7.0405443E 01
1.4200000E 04	8.5532037E 03	6.9446842E 01	8.9999987E 01	9.9226773E-01	-0.0000000E-39	0.0000000E-39
2.1399999E 04	-5.2500870E-01	-6.9915876E-01	0.0000000E-39	7.6445711E-01	7.6445710E-01	1.3816030E-10
1.5974452E 04	1.0000001E 00	9.0000000E 01	1.4497929E-05	1.6451040E 03	1.5868946E-03	7.1333328E 01
1.4400000E 04	8.4115997E 03	6.8212914E 01	8.9999987E 01	9.9226717E-01	-0.0000000E-39	0.0000000E-39
2.1694843E 04	-5.3382881E-01	-6.6807187E-01	0.0000000E-39	7.3129323E-01	7.3129321E-01	4.6449985E-10
1.6205602E 04	1.0000000E 00	9.0000000E 01	1.5111310E-05	1.7778818E 03	4.2381968E-03	7.2316142E 01
1.4600000E 04	8.2603882E 03	6.6954459E 01	8.9999987E 01	9.9226516E-01	-0.0000000E-39	0.0000000E-39
2.2015295E 04	-5.3594627E-01	-6.3053519E-01	0.0000000E-39	6.8481304E-01	6.8481303E-01	1.7747449E-09
1.6443082E 04	1.0000000E 00	9.0000000E 01	1.6286408E-05	1.9520851E 03	1.2101202E-02	7.3384317E 01
1.4800000E 04	8.0969135E 03	6.5651290E 01	8.9999987E 01	9.9225663E-01	-0.0000000E-39	0.0000000E-39
2.2380177E 04	-5.2627038E-01	-5.8162571E-01	0.0000000E-39	6.1524900E-01	6.1524897E-01	8.1507641E-09
1.6690746E 04	9.9999999E-01	9.0000000E 01	2.0763987E-05	2.1921001E 03	3.7627766E-02	7.4600591E 01
1.5000000E 04	7.9145271E 03	6.4256299E 01	8.9999987E 01	9.9220926E-01	-0.0000000E-39	0.0000000E-39
2.2839184E 04	-4.9049036E-01	-5.0817310E-01	0.0000000E-39	4.9882070E-01	4.9882069E-01	5.1968114E-08
1.6957711E 04	1.0000000E 00	9.0000000E 01	3.6778884E-05	2.5517022E 03	1.3343921E-01	7.6130611E 01
1.5200000E 04	7.6847656E 03	6.2571919E 01	8.9999987E 01	9.9166191E-01	-0.0000000E-39	0.0000000E-39
2.3653292E 04	-3.4888537E-01	-3.3667156E-01	0.0000000E-39	2.3506875E-01	2.3506874E-01	9.9657889E-07
1.7282348E 04	1.0000003E 00	9.0000000E 01	2.0589124E-04	3.2418612E 03	6.5767968E-01	7.8844307E 01

MAIN EMUS = -0.35763E-06

1.5252622E 04	7.5721335E 03	6.1769220E 01	8.9999987E 01	9.8841253E-01	0.0000000E-39	0.0000000E-39
2.4828140E 04	8.6445506E-05	-2.3048930E-04	-0.0000000E-39	-3.5762787E-07	6.0598143E-08	2.1926464E 00
1.7437619E 04	2.4903268E 00	9.0000010E 01	-1.9078991E 05	3.7784719E 03	1.4376653E 00	8.2760466E 01

```
C

INITIAL RAY POSITION                    INITIAL RAY DIRECTION

RO          9295.19                     AO        65.99
THETA0        77.44                     BO         0.00
PHI0          90.00                     DELAO      0.00

RAY CHARACTERISTICS                     FIELD LINE

FREQ     1.00                           LAMBDA    53.94
MODE    -1                              L-VALUE    1.53

            STOP CONDITIONS             INTERVALS
              MAX         MIN
RADIUS     20000.0     6378.0           PRINT    200.0
THETA        180.0        0.0           PLOT     100.0
PHI          360.0        0.0           STEP      20.0

PROGRAM OPTIONS                         OTHER INITIAL VALUES

NPOWER  0                               SCALE SIZE      0.707
NPLOT   1                               PKFRAC          0.050
NOVER   0                               HPRIME          1.176
NAUTO   0                               PKDFLN         60.553
JTEST   2
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C PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION - MOD AND ARG	COLATITUDE Y2	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
2.0000000E 01	9.3039232E 03	7.7566594E 01	8.9999987E 01	9.9999999E-01	0.0000000E-39	0.0000000E-39
2.4032085E 01	3.7294975E-01	8.4846694E-01	-0.0000000E-39	8.5898767E-01	8.5898766E-01	3.2931667E-13
2.1583472E 01	1.0000002E 00	-9.0000000E 01	1.6469652E-05	1.2074858E 03	8.7041584E-06	8.0106949E-02
2.0000000E 02	9.3790900E 03	7.8662731E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3919744E 02	3.4836922E-01	8.6207860E-01	0.0000000E-39	8.6454064E-01	8.6454062E-01	1.8389052E-13
2.1547629E 02	1.0000012E 00	-9.0000000E 01	1.4166274E-05	1.1775117E 03	5.1695189E-06	7.9732478E-01
4.0000000E 02	9.4551005E 03	7.9884624E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.7618564E 02	3.1347375E-01	8.7834971E-01	0.0000000E-39	8.6976400E-01	8.6976399E-01	1.0227621E-13
4.3024089E 02	9.9999999E-01	-9.0000000E 01	1.1866743E-05	1.1486229E 03	3.0524584E-06	1.5872855E 00
6.0000000E 02	9.5232367E 03	8.1110411E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
7.1136462E 02	2.7713870E-01	8.9294265E-01	0.0000000E-39	8.7415246E-01	8.7415243E-01	6.0566377E-14
6.4441425E 02	1.0000007E 00	-9.0000000E 01	1.5025012E-05	1.1237602E 03	1.9035364E-06	2.3712154E 00
8.0000000E 02	9.5830220E 03	8.2340661E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
9.4506214E 02	2.4415679E-01	9.0454189E-01	0.0000000E-39	8.7780859E-01	8.7780856E-01	3.8294271E-14
8.5809727E 02	1.0000001E 00	-9.0000000E 01	1.7477239E-05	1.1025771E 03	1.2578231E-06	3.1502071E 00
1.0000000E 03	9.6340448E 03	8.3575341E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.1775512E 03	2.0817369E-01	9.1513752E-01	0.0000000E-39	8.8081297E-01	8.8081296E-01	2.5913750E-14
1.0713757E 03	1.0000007E 00	-9.0000000E 01	1.3846845E-05	1.0847974E 03	8.8320766E-07	3.9251707E 00
1.2000000E 03	9.6764625E 03	8.4813458E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.4090666E 03	1.6666775E-01	9.2491707E-01	0.0000000E-39	8.8324974E-01	8.8324972E-01	1.8735864E-14
1.2843248E 03	1.0000002E 00	-9.0000000E 01	1.3299936E-05	1.0700573E 03	6.5827430E-07	4.6968887E 00
1.4000000E 03	9.7101851E 03	8.6054524E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.6398160E 03	1.2717220E-01	9.3220177E-01	0.0000000E-39	8.8517293E-01	8.8517290E-01	1.4476953E-14
1.4970122E 03	1.0000003E 00	-9.0000000E 01	1.7301383E-05	1.0581417E 03	5.2109726E-07	5.4660533E 00
1.6000000E 03	9.7346810E 03	8.7298237E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
1.8699844E 03	9.0446675E-02	9.3724206E-01	0.0000000E-39	8.8660328E-01	8.8660327E-01	1.1998679E-14
1.7094991E 03	1.0000006E 00	-9.0000000E 01	1.6676506E-05	1.0490151E 03	4.3974591E-07	6.2332812E 00
1.8000000E 03	9.7499128E 03	8.8543625E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.0997405E 03	4.8520172E-02	9.4085938E-01	0.0000000E-39	8.8757059E-01	8.8757058E-01	1.0667616E-14
1.9218418E 03	1.0000000E 00	-9.0000000E 01	1.3323439E-05	1.0425515E 03	3.9570018E-07	6.9991349E 00
2.0000000E 03	9.7561775E 03	8.9789761E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3292446E 03	4.7936449E-03	9.4238210E-01	0.0000000E-39	8.8810702E-01	8.8810700E-01	1.0149667E-14
2.1340945E 03	1.0000007E 00	-9.0000000E 01	1.5319731E-05	1.0385822E 03	3.7888778E-07	7.7641487E 00
2.0260837E 03	9.7562467E 03	8.9952306E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.3591659E 03	-2.4456811E-05	9.4241296E-01	0.0000000E-39	8.8814222E-01	8.8814219E-01	1.0141084E-14
2.1617723E 03	1.0000004E 00	-9.0000000E 01	1.4083907E-05	1.0382693E 03	3.7870657E-07	7.8638863E 00

RDOT =   -0.324365E-09

C

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
2.2000000E 03	9.7532346E 03	9.1036067E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.5587015E 03	-3.3936011E-02	9.4162404E-01	0.0000000E-39	8.8780750E-01	8.8780747E-01	1.0394681E-14
2.3463297E 03	9.9999999E-01	-9.0000000E 01	1.0152613E-05	1.0408803E 03	3.8668870E-07	8.5290051E 00
2.4000000E 03	9.7408164E 03	9.2281754E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
2.7883557E 03	-7.2818894E-02	9.3897601E-01	0.0000000E-39	8.8697855E-01	8.8697854E-01	1.1445093E-14
2.5586364E 03	1.0000006E 00	-9.0000000E 01	1.4817140E-05	1.0465529E 03	4.2143457E-07	9.2945191E 00
2.6000000E 03	9.7193019E 03	9.3520001E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.0183659E 03	-1.1610567E-01	9.3592753E-01	0.0000000E-39	8.8570116E-01	8.8570115E-01	1.3500052E-14
2.7710682E 03	1.0000001E 00	-9.0000000E 01	1.3307696E-05	1.0548087E 03	4.8918262E-07	1.0061220E 01
2.8000000E 03	9.6889330E 03	9.4763252E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.2488991E 03	-1.5647718E-01	9.2707807E-01	0.0000000E-39	8.8395886E-01	8.8395885E-01	1.7031583E-14
2.9836812E 03	1.0000005E 00	-9.0000000E 01	1.6800964E-05	1.0656973E 03	6.0374732E-07	1.0829664E 01
3.0000000E 03	9.6494663E 03	9.6007515E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.4801351E 03	-1.9188669E-01	9.1917433E-01	0.0000000E-39	8.8170196E-01	8.8170195E-01	2.3030040E-14
3.1965352E 03	1.0000004E 00	-9.0000000E 01	1.6751295E-05	1.0794545E 03	7.9364087E-07	1.1600450E 01
3.2000000E 03	9.6010636E 03	9.7243036E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.7122710E 03	-2.3005522E-01	9.0882241E-01	0.0000000E-39	8.7888360E-01	8.7888357E-01	3.3349983E-14
3.4096945E 03	1.0000001E 00	-9.0000000E 01	1.2921440E-05	1.0962617E 03	1.1099250E-06	1.2374237E 01
3.4000000E 03	9.5442659E 03	9.8474867E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
3.9455315E 03	-2.6915673E-01	8.9611009E-01	0.0000000E-39	8.7545864E-01	8.7545863E-01	5.1535437E-14
3.6232317E 03	1.0000007E 00	-9.0000000E 01	1.3783289E-05	1.1162475E 03	1.6452545E-06	1.3151772E 01
3.6000000E 03	9.4791589E 03	9.9702653E 01	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.1801774E 03	-3.0268168E-01	8.8302022E-01	0.0000000E-39	8.7134092E-01	8.7134090E-01	8.4979735E-14
3.8372293E 03	1.0000001E 00	-9.0000000E 01	1.6982257E-05	1.1397493E 03	2.5833914E-06	1.3933925E 01
3.8000000E 03	9.4056719E 03	1.0092565E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.4165156E 03	-3.3554193E-01	8.6893855E-01	0.0000000E-39	8.6640873E-01	8.6640869E-01	1.4972562E-13
4.0517824E 03	1.0000006E 00	-9.0000000E 01	1.4573974E-05	1.1672594E 03	4.2992075E-06	1.4721719E 01
4.0000000E 03	9.3242083E 03	1.0214423E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.6549172E 03	-3.6072053E-01	8.5208294E-01	0.0000000E-39	8.6052931E-01	8.6052927E-01	2.8128736E-13
4.2670035E 03	9.9999999E-01	-9.0000000E 01	1.1754524E-05	1.1992414E 03	7.5616214E-06	1.5516391E 01
4.2000000E 03	9.2351743E 03	1.0335929E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
4.8958437E 03	-3.9829176E-01	8.3360097E-01	0.0000000E-39	8.5352691E-01	8.5352689E-01	5.6242231E-13
4.4830295E 03	1.0000009E 00	-9.0000000E 01	1.3437236E-05	1.2363054E 03	1.4016773E-05	1.6319479E 01
4.4000000E 03	9.1385934E 03	1.0457108E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.1398819E 03	-4.2449239E-01	8.1544024E-01	0.0000000E-39	8.4513658E-01	8.4513656E-01	1.1984651E-12
4.7000301E 03	1.0000000E 00	-9.0000000E 01	1.5997801E-05	1.2794220E 03	2.7379573E-05	1.7132940E 01

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PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION - MOD AND ARG	COLATITUDE Y2	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
4.6000000E 03	9.0344534E 03	1.0577993E 02	8.9999987E 01	9.9999999E-01	-0.0000000E-39	0.0000000E-39
5.3877957E 03	-4.4820698E-01	7.9630570E-01	0.0000000E-39	8.3499229E-01	8.3499227E-01	2.7273660E-12
4.9182202E 03	1.0000006E 00	-9.0000000E 01	1.3783368E-05	1.3299086E 03	5.6363433E-05	1.7959319E 01
4.8000000E 03	8.9229851E 03	1.0698758E 02	8.9999987E 01	9.9999998E-01	-0.0000000E-39	0.0000000E-39
5.6406133E 03	-4.7247833E-01	7.7418749E-01	0.0000000E-39	8.2260205E-01	8.2260203E-01	6.6340648E-12
5.1378809E 03	1.0000000E 00	-9.0000000E 01	1.1102887E-05	1.3894372E 03	1.2208703E-04	1.8802044E 01
5.0000000E 03	8.8043370E 03	1.0819654E 02	8.9999987E 01	9.9999996E-01	-0.0000000E-39	0.0000000E-39
5.8997706E 03	-4.9495025E-01	7.4985154E-01	0.0000000E-39	8.0725309E-01	8.0725307E-01	1.7287982E-11
5.3593929E 03	1.0000007E 00	-9.0000000E 01	1.1611349E-05	1.4603705E 03	2.7797160E-04	1.9665902E 01
5.2000000E 03	8.6783485E 03	1.0940955E 02	8.9999987E 01	9.9999990E-01	-0.0000000E-39	0.0000000E-39
6.1673580E 03	-5.1280068E-01	7.2449033E-01	0.0000000E-39	7.8785077E-01	7.8785077E-01	4.8560328E-11
5.5832910E 03	1.0000010E 00	-9.0000000E 01	1.4284647E-05	1.5462582E 03	6.6601317E-04	2.0557860E 01
5.4000000E 03	8.5445992E 03	1.1063033E 02	8.9999987E 01	9.9999971E-01	-0.0000000E-39	0.0000000E-39
6.4465814E 03	-5.2537873E-01	6.9759721E-01	0.0000000E-39	7.6266468E-01	7.6266467E-01	1.4855589E-10
5.8103626E 03	9.9999999E-01	-9.0000000E 01	1.5901231E-05	1.6524843E 03	1.6842028E-03	2.1488604E 01
5.6000000E 03	8.4024056E 03	1.1186527E 02	8.9999987E 01	9.9999911E-01	-0.0000000E-39	0.0000000E-39
6.7427059E 03	-5.3338426E-01	6.6658556E-01	0.0000000E-39	7.2883508E-01	7.2883508E-01	5.0310463E-10
6.0418395E 03	1.0000006E 00	-9.0000000E 01	1.5228258E-05	1.7874207E 03	4.5165364E-03	2.2475686E 01
5.8000000E 03	8.2504941E 03	1.1312562E 02	8.9999987E 01	9.9999690E-01	-0.0000000E-39	0.0000000E-39
7.0652397E 03	-5.3525086E-01	6.2830439E-01	0.0000000E-39	6.8125990E-01	6.8125989E-01	1.9409943E-09
6.2798168E 03	1.0000005E 00	-9.0000000E 01	1.5642431E-05	1.9649102E 03	1.2958793E-02	2.3550799E 01
6.0000000E 03	8.0860879E 03	1.1443262E 02	8.9999987E 01	9.9998741E-01	-0.0000000E-39	0.0000000E-39
7.4340067E 03	-5.2499031E-01	5.7799308E-01	0.0000000E-39	6.0969083E-01	6.0969082E-01	9.0477102E-09
6.5283325E 03	1.0000000E 00	-9.0000000E 01	2.0518218E-05	2.2103736E 03	4.0555973E-02	2.4780022E 01
6.2000000E 03	7.9020624E 03	1.1583653E 02	8.9999987E 01	9.9993349E-01	-0.0000000E-39	0.0000000E-39
7.9025547E 03	-4.8676638E-01	5.0175183E-01	0.0000000E-39	4.8869641E-01	4.8869640E-01	5.9504748E-08
6.7971226E 03	1.0000003E 00	-9.0000000E 01	3.8403949E-05	2.5809750E 03	1.4547056E-01	2.6341849E 01
6.4000000E 03	7.6653594E 03	1.1756683E 02	8.9999987E 01	9.9923335E-01	-0.0000000E-39	0.0000000E-39
8.7833248E 03	-3.2390833E-01	3.1156787E-01	0.0000000E-39	2.0199116E-01	2.0199115E-01	1.4098117E-06
7.1307551E 03	1.0000021E 00	-9.0000000E 01	2.7638541E-04	3.3205346E 03	7.5239098E-01	2.9277749E 01
6.4400566E 03	7.5721304E 03	1.1823051E 02	8.9999987E 01	9.9611150E-01	-0.0000000E-39	0.0000000E-39
9.8577780E 03	4.8961587E-04	1.0878130E-03	0.0000000E-39	1.4230609E-06	1.4230609E-06	9.2317578E-01
7.2591330E 03	2.9313798E 00	-8.9999988E 01	3.9348341E 04	3.7784882E 03	1.4374013E 00	3.2859260E 01
ROOT =	0.119733E 03					
6.6000000E 03	7.8181928E 03	1.1645444E 02	8.9999987E 01	9.9242402E-01	-0.0000000E-39	0.0000000E-39
1.1549916E 04	4.5106217E-01	-4.5505125E-01	0.0000000E-39	4.1052873E-01	4.1052872E-01	1.5544319E-07
7.6019037E 03	1.0000016E 00	9.0000000E 01	5.9383944E-05	2.7982431E 03	2.6039533E-01	3.8499721E 01

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PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
6.8000000E 03	8.0153330E 03	1.1497738E 02	8.9999987E 01	9.9229947E-01	-0.0000000E-39	0.0000000E-39
1.2100996E 04	6.1097861E-01	-5.5545828E-01	0.0000000E-39	5.6963304E-01	5.6963303E-01	1.8184772E-08
7.8857042E 03	1.0000138E 00	9.0000000E 01	2.3742982E-05	2.3385556E 03	6.6271536E-02	4.0336654E 01
7.0000000E 03	8.1865252E 03	1.1364226E 02	8.9999987E 01	9.9228141E-01	-0.0000000E-39	0.0000000E-39
1.2499484E 04	6.2885737E-01	-6.1377509E-01	0.0000000E-39	6.5640998E-01	6.5640996E-01	3.4926194E-09
8.1405604E 03	1.0000194E 00	9.0000000E 01	2.0575027E-05	2.0527854E 03	2.0199563E-02	4.1664945E 01
7.2000000E 03	8.3430880E 03	1.1230723E 02	8.9999987E 01	9.9227757E-01	-0.0000000E-39	0.0000000E-39
1.2837181E 04	6.3702185E-01	-6.5077586E-01	0.0000000E-39	7.1190169E-01	7.1190167E-01	8.4680160E-10
8.3820966E 03	1.0000005E 00	9.0000000E 01	2.7577250E-05	1.8520632E 03	6.8160733E-03	4.2790603E 01
7.4000000E 03	8.4887042E 03	1.1112236E 02	8.9999987E 01	9.9227658E-01	-0.0000000E-39	0.0000000E-39
1.3142378E 04	6.3553221E-01	-6.8086596E-01	0.0000000E-39	7.5037321E-01	7.5037320E-01	2.3892542E-10
8.6158564E 03	1.0000195E 00	9.0000000E 01	1.4429818E-05	1.7024764E 03	2.4819458E-03	4.3807926E 01
7.6000000E 03	8.6254446E 03	1.0989553E 02	8.9999987E 01	9.9227629E-01	-0.0000000E-39	0.0000000E-39
1.3427567E 04	6.2057907E-01	-7.1241779E-01	0.0000000E-39	7.7854168E-01	7.7854166E-01	7.5342794E-11
8.8445065E 03	1.0000049E 00	9.0000000E 01	7.6741700E-06	1.5861974E 03	9.6128929E-04	4.4758558E 01
7.8000000E 03	8.7545413E 03	1.0866042E 02	8.9999987E 01	9.9227619E-01	-0.0000000E-39	0.0000000E-39
1.3699339E 04	4.9832508E-01	-7.4275952E-01	0.0000000E-39	8.0001961E-01	8.0001958E-01	2.5946676E-11
9.0695627E 03	1.0000030E 00	9.0000000E 01	7.2116479E-06	1.4928716E 03	3.9263385E-04	4.5664464E 01
8.0000000E 03	8.8764985E 03	1.0747194E 02	8.9999987E 01	9.9227616E-01	-0.0000000E-39	0.0000000E-39
1.3961574E 04	4.7590920E-01	-7.6836877E-01	0.0000000E-39	8.1688014E-01	8.1688013E-01	9.6403118E-12
9.2919552E 03	1.0000113E 00	9.0000000E 01	1.5808573E-05	1.4162165E 03	1.6852501E-04	4.6538579E 01
8.2000000E 03	8.9909630E 03	1.0626442E 02	8.9999987E 01	9.9227615E-01	-0.0000000E-39	0.0000000E-39
1.4216733E 04	4.6209006E-01	-7.8536670E-01	0.0000000E-39	8.3035952E-01	8.3035950E-01	3.8537134E-12
9.5123059E 03	1.0000026E 00	9.0000000E 01	2.2830800E-05	1.3524099E 03	7.6199617E-05	4.7389109E 01
8.4000000E 03	9.0975846E 03	1.0505457E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4466469E 04	4.4025101E-01	-8.0465734E-01	0.0000000E-39	8.4129439E-01	8.4129438E-01	1.6552251E-12
9.7310469E 03	1.0000096E 00	9.0000000E 01	9.6646328E-06	1.2987617E 03	3.6383688E-05	4.8221563E 01
8.6000000E 03	9.1970591E 03	1.0384374E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4711952E 04	4.0017660E-01	-8.2785741E-01	0.0000000E-39	8.5032735E-01	8.5032732E-01	7.5757118E-13
9.9484939E 03	1.0000006E 00	9.0000000E 01	6.8744184E-06	1.2529211E 03	1.8256042E-05	4.9039841E 01
8.8000000E 03	9.2896071E 03	1.0263151E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.4954046E 04	3.7270744E-01	-8.4792249E-01	0.0000000E-39	8.5788339E-01	8.5788337E-01	3.6803251E-13
1.0164887E 04	1.0000090E 00	9.0000000E 01	1.5956494E-05	1.2133702E 03	9.6111444E-06	4.9846818E 01
9.0000000E 03	9.3742843E 03	1.0141471E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5193400E 04	3.5167662E-01	-8.6053364E-01	0.0000000E-39	8.6419459E-01	8.6419458E-01	1.9084091E-13
1.0380414E 04	1.0000029E 00	9.0000000E 01	2.2390344E-05	1.1793927E 03	5.3439853E-06	5.0644666E 01

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PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CD
RAY PATH	POLARIZATION -	MOD AND ARG	DEL MU	N	NU	GROUP DELAY
9.2000000E 03	9.4504237E 03	1.0019217E 02	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5430516E 04	3.2061915E-01	-8.7559040E-01	0.0000000E-39	8.6945521E-01	8.6945518E-01	1.0601537E-13
1.0595220E 04	1.0000054E 00	9.0000000E 01	9.4049451E-06	1.1503586E 03	3.1527372E-06	5.1435053E 01
9.4000000E 03	9.5189124E 03	9.8966430E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5665797E 04	2.7722088E-01	-8.9276735E-01	0.0000000E-39	8.7388499E-01	8.7388496E-01	6.2603361E-14
1.0809427E 04	1.0000032E 00	9.0000000E 01	8.9807132E-06	1.1253020E 03	1.9613061E-06	5.2219324E 01
9.6000000E 03	9.5796604E 03	9.7737236E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.5899580E 04	2.4152758E-01	-9.0513543E-01	0.0000000E-39	8.7760573E-01	8.7760571E-01	3.9290832E-14
1.1023138E 04	1.0000031E 00	9.0000000E 01	2.2039917E-05	1.1037627E 03	1.2873662E-06	5.2998599E 01
9.8000000E 03	9.6312145E 03	9.6502707E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6132139E 04	2.1531682E-01	-9.1339286E-01	0.0000000E-39	8.8064785E-01	8.8064783E-01	2.6479376E-14
1.1236441E 04	1.0000079E 00	9.0000000E 01	1.7245094E-05	1.0857864E 03	9.0064015E-07	5.3773798E 01
1.0000000E 04	9.6737740E 03	9.5264329E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6363710E 04	1.7132190E-01	-9.2398523E-01	0.0000000E-39	8.8309991E-01	8.8309988E-01	1.9123235E-14
1.1449408E 04	1.0000002E 00	9.0000000E 01	8.3066135E-06	1.0709788E 03	6.7062638E-07	5.4545699E 01
1.0200000E 04	9.7082472E 03	9.4023710E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6594501E 04	1.2416565E-01	-9.3254848E-01	0.0000000E-39	8.8506378E-01	8.8506377E-01	1.4692298E-14
1.1662110E 04	1.0000077E 00	9.0000000E 01	1.5133477E-05	1.0588326E 03	5.2812315E-07	5.5315002E 01
1.0400000E 04	9.7336588E 03	9.2780326E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.6824702E 04	9.3664411E-02	-9.3689085E-01	0.0000000E-39	8.8653749E-01	8.8653748E-01	1.2093528E-14
1.1874608E 04	1.0000011E 00	9.0000000E 01	2.3721450E-05	1.0494419E 03	4.4285535E-07	5.6082339E 01
1.0600000E 04	9.7490923E 03	9.1534812E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7054480E 04	5.5869649E-02	-9.4042350E-01	0.0000000E-39	8.8751779E-01	8.8751777E-01	1.0735285E-14
1.2086959E 04	1.0000046E 00	9.0000000E 01	1.0955231E-05	1.0429188E 03	3.9795258E-07	5.6848267E 01
1.0800000E 04	9.7558131E 03	9.0288774E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7283994E 04	4.7762435E-03	-9.4236594E-01	0.0000000E-39	8.8807640E-01	8.8807637E-01	1.0178964E-14
1.2299215E 04	1.0000034E 00	9.0000000E 01	1.0382043E-05	1.0388236E 03	3.7984839E-07	5.7613314E 01
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858762E-05	-9.4240142E-01	0.0000000E-39	8.8812046E-01	8.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT =	0.304660E-09					
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858498E-05	-9.4240142E-01	0.0000000E-39	8.8812046E-01	8.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT =	0.112647E-10					
1.0862875E 04	9.7559785E 03	8.9896946E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7356121E 04	5.2858488E-05	-9.4240142E-01	0.0000000E-39	8.8812046E-01	8.8812044E-01	1.0162559E-14
1.2365933E 04	1.0000018E 00	9.0000000E 01	9.5427146E-06	1.0384425E 03	3.7941475E-07	5.7853736E 01
RDOT =	-0.000000E-38					

C

PHASE PATH	RADIUS	COLATITUDE	LONGITUDE	ABSORPTION	DOPPLER SP	POWER LOSS
GROUP PATH	Y1	Y2	Y3	MU**2	Y**2	EPSTEIN CD
RAY PATH	POLARIZATION - MOD AND ARG		DEL MU	N	NU	GROUP DELAY
1.1000000E 04	9.7538746E 03	8.9042443E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7513446E 04	-3.5245760E-02	-9.4159958E-01	0.0000000E-39	8.8785204E-01	8.8785202E-01	1.0343140E-14
1.2511448E 04	1.0000022E 00	9.0000000E 01	2.3012678E-05	1.0405631E 03	3.8497870E-07	5.8378152E 01
1.1200000E 04	9.7419417E 03	8.7796659E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7743084E 04	-6.5370599E-02	-9.3956067E-01	0.0000000E-39	8.8704756E-01	8.8704755E-01	1.1346602E-14
1.2723750E 04	1.0000074E 00	9.0000000E 01	1.6700121E-05	1.0460998E 03	4.1816919E-07	5.9143615E 01
1.1400000E 04	9.7206520E 03	8.6552547E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.7973067E 04	-1.1258842E-01	-9.3446226E-01	0.0000000E-39	8.8578375E-01	8.8578374E-01	1.3360989E-14
1.2936172E 04	9.9999999E-01	9.0000000E 01	8.4944277E-06	1.0542867E 03	4.8464928E-07	5.9910223E 01
1.1600000E 04	9.6911000E 03	8.5310000E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8203562E 04	-1.5918176E-01	-9.2684476E-01	0.0000000E-39	8.8408347E-01	8.8408346E-01	1.6752208E-14
1.3148771E 04	1.0000079E 00	9.0000000E 01	1.6225409E-05	1.0649328E 03	5.9477699E-07	6.0678538E 01
1.1800000E 04	9.6524272E 03	8.4070226E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8434749E 04	-1.8763440E-01	-9.2014293E-01	0.0000000E-39	8.8186968E-01	8.8186967E-01	2.2516394E-14
1.3361609E 04	1.0000019E 00	9.0000000E 01	2.2908939E-05	1.0784390E 03	7.7756054E-07	6.1449163E 01
1.2000000E 04	9.6042000E 03	8.2834958E 01	8.9999987E 01	9.9227614E-01	-0.0000000E-39	0.0000000E-39
1.8666823E 04	-2.2398147E-01	-9.1044134E-01	0.0000000E-39	8.7907113E-01	8.7907112E-01	3.2560243E-14
1.3574747E 04	1.0000038E 00	9.0000000E 01	9.7715355E-06	1.0951607E 03	1.0861438E-06	6.2222742E 01
1.2200000E 04	9.5478989E 03	8.1603024E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.8900004E 04	-2.6985149E-01	-8.9602736E-01	0.0000000E-39	8.7568486E-01	8.7568486E-01	5.0121591E-14
1.3786258E 04	1.0000045E 00	9.0000000E 01	9.6153893E-06	1.1149483E 03	1.6044905E-06	6.3000012E 01
1.2400000E 04	9.4836815E 03	8.0374266E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9134554E 04	-3.0355927E-01	-8.8283398E-01	0.0000000E-39	8.7163236E-01	8.7163235E-01	8.2083085E-14
1.4002224E 04	1.0000027E 00	9.0000000E 01	2.2332335E-05	1.1380990E 03	2.5038823E-06	6.3781848E 01
1.2600000E 04	9.4105884E 03	7.9151181E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9370778E 04	-3.2702917E-01	-8.7166581E-01	0.0000000E-39	8.6674938E-01	8.6674935E-01	1.4416212E-13
1.4216740E 04	1.0000082E 00	9.0000000E 01	1.6083744E-05	1.1653835E 03	4.1555854E-06	6.4569258E 01
1.2800000E 04	9.3293307E 03	7.7933098E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9609036E 04	-3.6371978E-01	-8.5559492E-01	0.0000000E-39	8.6091638E-01	8.6091636E-01	2.7034880E-13
1.4431915E 04	1.0000002E 00	9.0000000E 01	7.2461871E-06	1.1971709E 03	7.2987398E-06	6.5363454E 01
1.3000000E 04	9.2409331E 03	7.6717456E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
1.9849787E 04	-4.0062893E-01	-8.3276558E-01	0.0000000E-39	8.5400207E-01	8.5400204E-01	5.3775775E-13
1.4647885E 04	1.0000094E 00	9.0000000E 01	1.1260223E-05	1.2338320E 03	1.3469925E-05	6.6165956E 01
1.3200000E 04	9.1450950E 03	7.5504608E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
2.0093610E 04	-4.2357370E-01	-8.1627955E-01	0.0000000E-39	8.4572700E-01	8.4572698E-01	1.1389420E-12
1.4864819E 04	1.0000004E 00	9.0000000E 01	2.3405390E-05	1.2764207E 03	2.6176049E-05	6.6978700E 01

C

PHASE PATH GROUP PATH RAY PATH	RADIUS Y1 POLARIZATION -	COLATITUDE Y2 MOD AND ARG	LONGITUDE Y3 DEL MU	ABSORPTION MU**2 N	DOPPLER SP Y**2 NU	POWER LOSS EPSTEIN CD GROUP DELAY
1.3400000E 04	9.0412096E 03	7.4296288E 01	8.9999987E 01	9.9227613E-01	-0.0000000E-39	0.0000000E-39
2.0341255E 04	-4.4229341E-01	-8.0004223E-01	0.0000000E-39	8.3569104E-01	8.3569102E-01	2.5854140E-12
1.5082927E 04	1.0000102E 00	9.0000000E 01	1.3188527E-05	1.3264922E 03	5.3791622E-05	6.7804183E 01
1.3600000E 04	8.9299915E 03	7.3089460E 01	8.9999987E 01	9.9227612E-01	-0.0000000E-39	0.0000000E-39
2.0593726E 04	-4.7049816E-01	-7.7593203E-01	0.0000000E-39	8.2343904E-01	8.2343902E-01	6.2723915E-12
1.5302485E 04	1.0000003E 00	9.0000000E 01	6.6921920E-06	1.3854996E 03	1.1631613E-04	6.8645753E 01
1.3800000E 04	8.8119235E 03	7.1880236E 01	8.9999987E 01	9.9227610E-01	-0.0000000E-39	0.0000000E-39
2.0852429E 04	-4.9729967E-01	-7.4900517E-01	0.0000000E-39	8.0831572E-01	8.0831569E-01	1.6256460E-11
1.5523866E 04	1.0000096E 00	9.0000000E 01	8.9132457E-06	1.4555654E 03	2.6376807E-04	6.9508097E 01
1.4000000E 04	8.6866577E 03	7.0666442E 01	8.9999987E 01	9.9227604E-01	-0.0000000E-39	0.0000000E-39
2.1119408E 04	-5.1445442E-01	-7.2427869E-01	0.0000000E-39	7.8924296E-01	7.8924296E-01	4.5345888E-11
1.5747595E 04	1.0000077E 00	9.0000000E 01	2.0426532E-05	1.5402129E 03	6.2881361E-04	7.0398026E 01
1.4200000E 04	8.5533727E 03	6.9446410E 01	8.9999987E 01	9.9227587E-01	-0.0000000E-39	0.0000000E-39
2.1397777E 04	-5.2098500E-01	-7.0218415E-01	0.0000000E-39	7.6448797E-01	7.6448794E-01	1.3796770E-10
1.5974438E 04	1.0000066E 00	9.0000000E 01	2.1027954E-05	1.6449653E 03	1.5850228E-03	7.1325923E 01
1.4400000E 04	8.4114847E 03	6.8213956E 01	8.9999987E 01	9.9227531E-01	-0.0000000E-39	0.0000000E-39
2.1692623E 04	-5.2955579E-01	-6.7144819E-01	0.0000000E-39	7.3127202E-01	7.3127200E-01	4.6493516E-10
1.6205589E 04	1.0000117E 00	9.0000000E 01	1.1226565E-05	1.7779944E 03	4.2416173E-03	7.2308743E 01
1.4600000E 04	8.2601404E 03	6.6956388E 01	8.9999987E 01	9.9227331E-01	-0.0000000E-39	0.0000000E-39
2.2013070E 04	-5.3554799E-01	-6.3081810E-01	0.0000000E-39	6.8474313E-01	6.8474312E-01	1.7785231E-09
1.6443067E 04	1.0000003E 00	9.0000000E 01	1.2084965E-05	1.9523911E 03	1.2122247E-02	7.3376900E 01
1.4800000E 04	8.0967217E 03	6.5653061E 01	8.9999987E 01	9.9226478E-01	-0.0000000E-39	0.0000000E-39
2.2377935E 04	-5.2901273E-01	-5.7906848E-01	0.0000000E-39	6.1517478E-01	6.1517477E-01	8.1647683E-09
1.6690728E 04	1.0000072E 00	9.0000000E 01	1.8152357E-05	2.1924089E 03	3.7678461E-02	7.4593117E 01
1.5000000E 04	7.9144752E 03	6.4257302E 01	8.9999987E 01	9.9221747E-01	-0.0000000E-39	0.0000000E-39
2.2836896E 04	-4.9463328E-01	-5.0412133E-01	0.0000000E-39	4.9880040E-01	4.9880040E-01	5.1992248E-08
1.6957685E 04	1.0000276E 00	9.0000000E 01	3.5783823E-05	2.5518166E 03	1.3348818E-01	7.6122987E 01
1.5200000E 04	7.6846954E 03	6.2573347E 01	8.9999987E 01	9.9167076E-01	-0.0000000E-39	0.0000000E-39
2.3650797E 04	-3.5242223E-01	-3.3286553E-01	0.0000000E-39	2.3500089E-01	2.3500088E-01	9.9749666E-07
1.7282301E 04	1.0000440E 00	9.0000000E 01	2.0531902E-04	3.2421275E 03	6.5800690E-01	7.8835991E 01

MAIN EMUS = -0.29802E-06

1.5252622E 04	7.5721128E 03	6.1770828E 01	8.9999987E 01	9.8845857E-01	0.0000000E-39	0.0000000E-39
2.4815457E 04	-4.0342019E-04	5.1147716E-04	-0.0000000E-39	-2.9802322E-07	4.2435672E-07	2.1138030E 00
1.7437529E 04	1.1212211E 01	-8.9999986E 01	-2.6547938E 05	3.7785821E 03	1.4378852E 00	8.2718190E 01

STR AT 01517 XR1= 00000 XR2= 75030 XR4= 31776 XR3= 46160 XR5= 00000 XR6= 00000 XR7= 00000

APPENDIX C

CHECKLIST OF ELEMENTS IN COMMON AND SUBROUTINE IN WHICH USED

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
/DATA/	X	X	X	X	X	X	X	X	
RMAX	X	X							
RMIN	X	X							
TMAX	X	X							
TMIN	X	X							
PMAX	X	X							
PMIN	X	X							
PRNT	X	X							
RELERR	Presently not used								
AØ		X							
BØ		X							
RØ		X	X			X			
THETAØ		X	X			X			
PHIØ		X	X			X			
PLUS	X	X						X	
NPØWER	X	X	X			X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
NPLØT		X	X						
J	X	X							
NUAR	X	X							
N1	X								
EN	X	X	X			X	X		
DNDR	X						X		
DNDT	X						X		
DNDP	X						X		
EMU	X	X	X		X				
RTYSQR	X			X	X				
F	X	X	X					X	
F2	X	X	X			X			
C1	X	X				X			
FH	X	X		X		X		X	
CØSPSI	X	X		X		X		X	
STNPSI	X	X		X		X		X	
DFHDR	X			X		X			
DCPDT	X			X		X			
DCPDY1	X			X		X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWERL	DENSE	POLAR	CALCO4
DCPDY2	X			X		X			
DCPDY3	X			X		X			
SP2	X			X					
EMUINT	X	X	X						
EMUS	X	X	X			X			
N	X		X						
GNU	X		X						
MUFLAG	X					X			
NTEST	Presently not used								
/HBANK1/	X	X	X	X	X	X	X	X	
MØRDER	Presently not used								
NØHALF	Presently not used								
NØDØUB	Presently not used								
HBANK	X	X							
NØEQ	Presently not used								
FINVP	Presently not used								
FINVPI	Presently not used								
YØ	X	X	X	X	X	X	X	X	
YD	X		X			X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWERL	DENSE	POLAR	CALCO4
MA	Presently not used								
/CSCR/	X	X	X	X		X		X	
C	X	X		X		X			
RCT	X		X			X			
S	X	X		X		X			
RST	X					X			
Z	X							X	
EM	X	X				X			
TERM	X	X				X			
TERM2	X	X				X			
RMØD			X					X	
RARG			X					X	
YØ6	Presently not used								
/CONST/	X	X							
ØRDER	X	X							
EUBAR	X	X							
ELBAR	X	X							
YCLØW	X	X							
HMAXT	X	X							

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
HMINT	X	X							
KD	X	X							
/NEW/	X	X							
PLØTØ	X	X							
RDØT	X	X							
/EPSTN/	X		X						
EPSTIN	X		X						
PRØPT	X		X						
/GAUSS/	X		X	X		X			
YSQUAR	X			X					
DCPDR	X			X		X			
DCPDP	X			X		X			
DFHDP	X			X		X			
F1T				X					
DNMNTR				X					
DEL2S			X			X			
/PØWLØS/	X		X			X			
CØSA	X					X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWERL	DENSE	POLAR	CALCO4
Y	X					X			
DMDR	X					X			
DMDT	X					X			
DMDP	X					X			
DMDY1	X					X			
DMDY2	X					X			
DMDY3	X					X			
DMDSI	X					X			
DMDDSI	X					X			
DMUDR	X		X			X			
DMUDT	X		X			X			
DMUDP	X		X			X			
DMUDY1	X					X			
DMUDY2	X					X			
DMUDY3	X					X			
DMUDSI	X					X			
EMD	X					X			
EMRAD	X					X			
/EXFLD/				X		X			

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
D2CY1R				X		X			
D2SY1R				X		X			
D2CY2T				X		X			
D2SY2T				X		X			
D2CY3P				X		X			
D2SY3P				X		X			
/GRAPHO/	X	X							X
XMAXO	X	X							X
XMINO	X	X							X
YMAXO	X	X							X
YMINO	X	X							X
DATE	X	X							X
/GRAPH1/	X	X							X
XMAX1	X	X							X
XMIN1	X	X							X
YMAX1	X	X							X
YMIN1	X	X							X
PLT	X	X							X
/RECT/	X		X				X		

	MAIN	INPUT	OUTPUT	FIELD	FORCE	POWER	DENSE	POLAR	CALCO4
DD	X		X				X		
SØA	X		X				X		
LB	X		X				X		
/RDØTS/	X		X						
JUMP	X		X						
NYD1	X		X						
/BLK1/		X					X		
STZM5		X					X		
HPRIME		X					X		
PKDELN		X					X		
AMBDL		X					X		
NO		X					X		

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